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GERB Operations Report

James Rufus

GIST 34 - Toulouse - 8th Oct 2014

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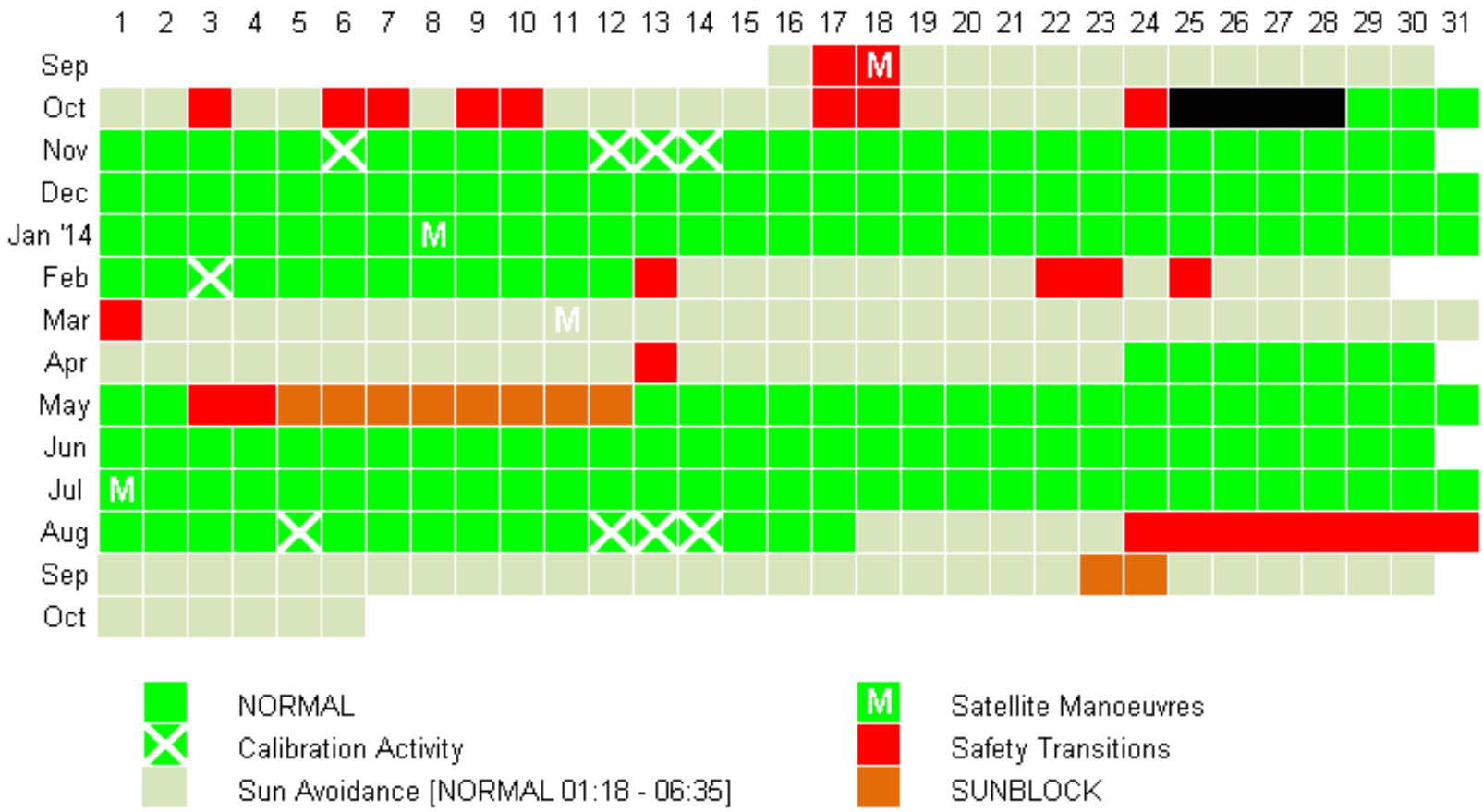
GERB-1 Operations since GIST 33



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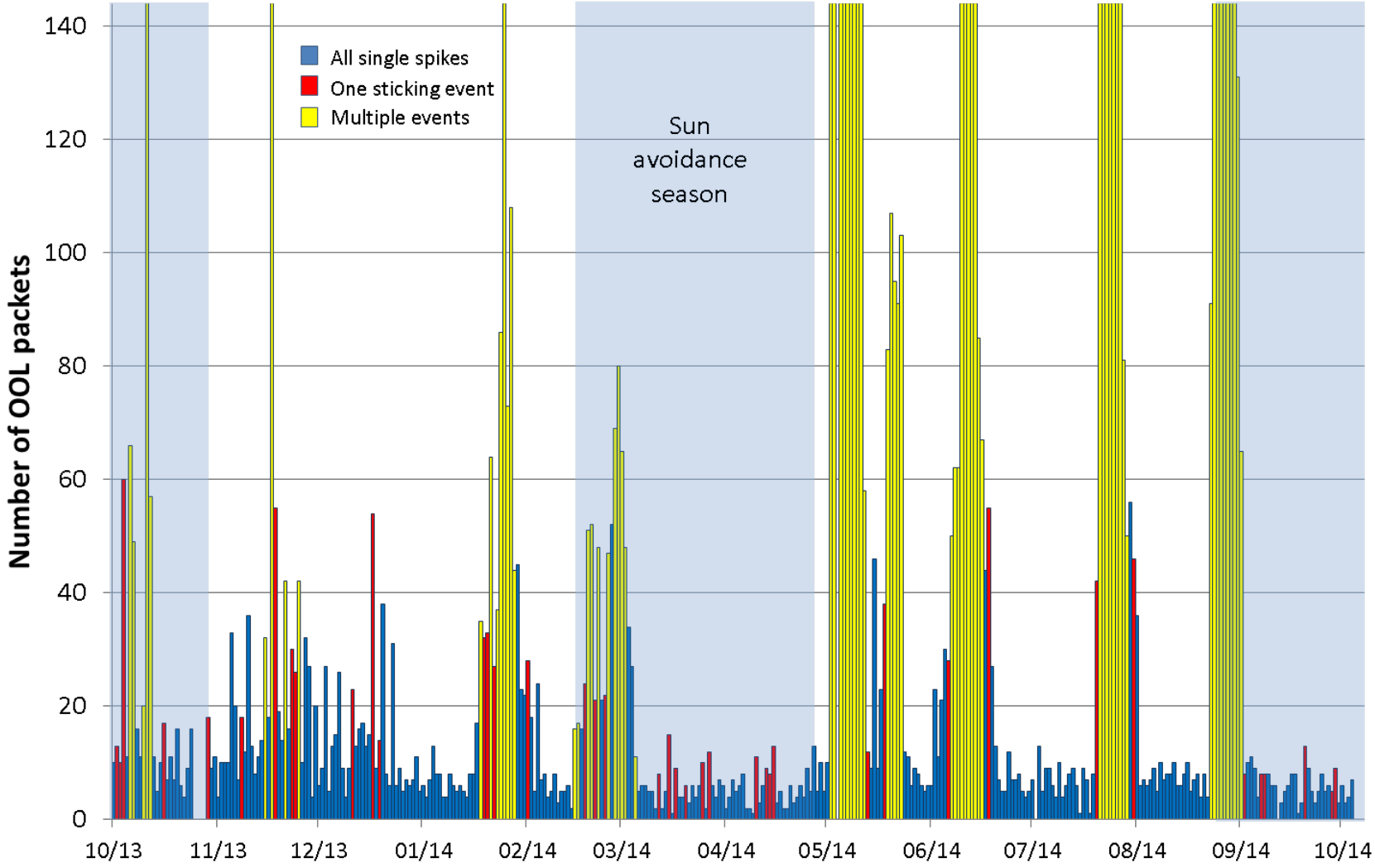
Daily GVMPERR OOL on GERB-1 Despin Mirror, 2013-14



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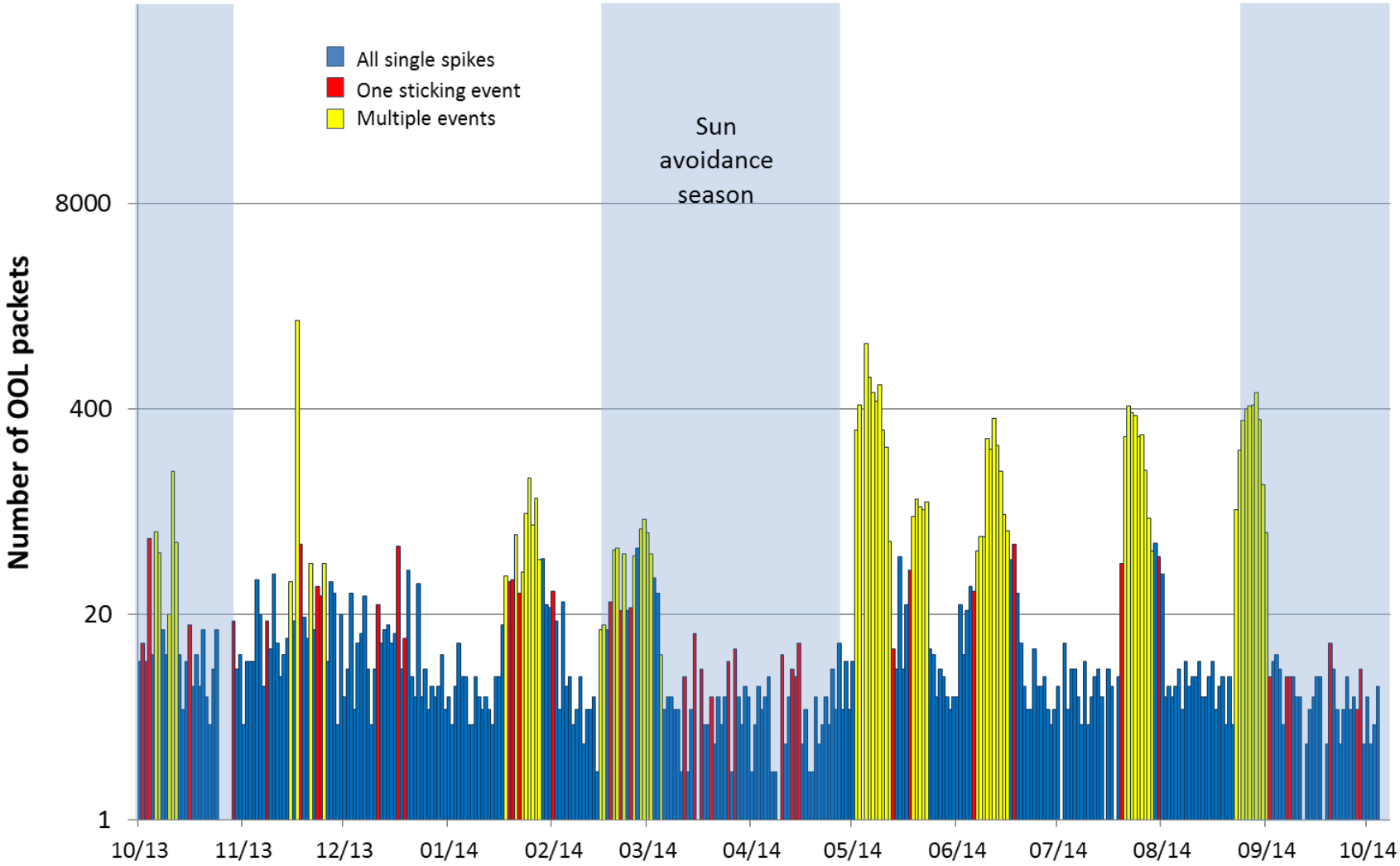
Daily GVMPERR OOL on GERB-1 Despin Mirror, 2013-14



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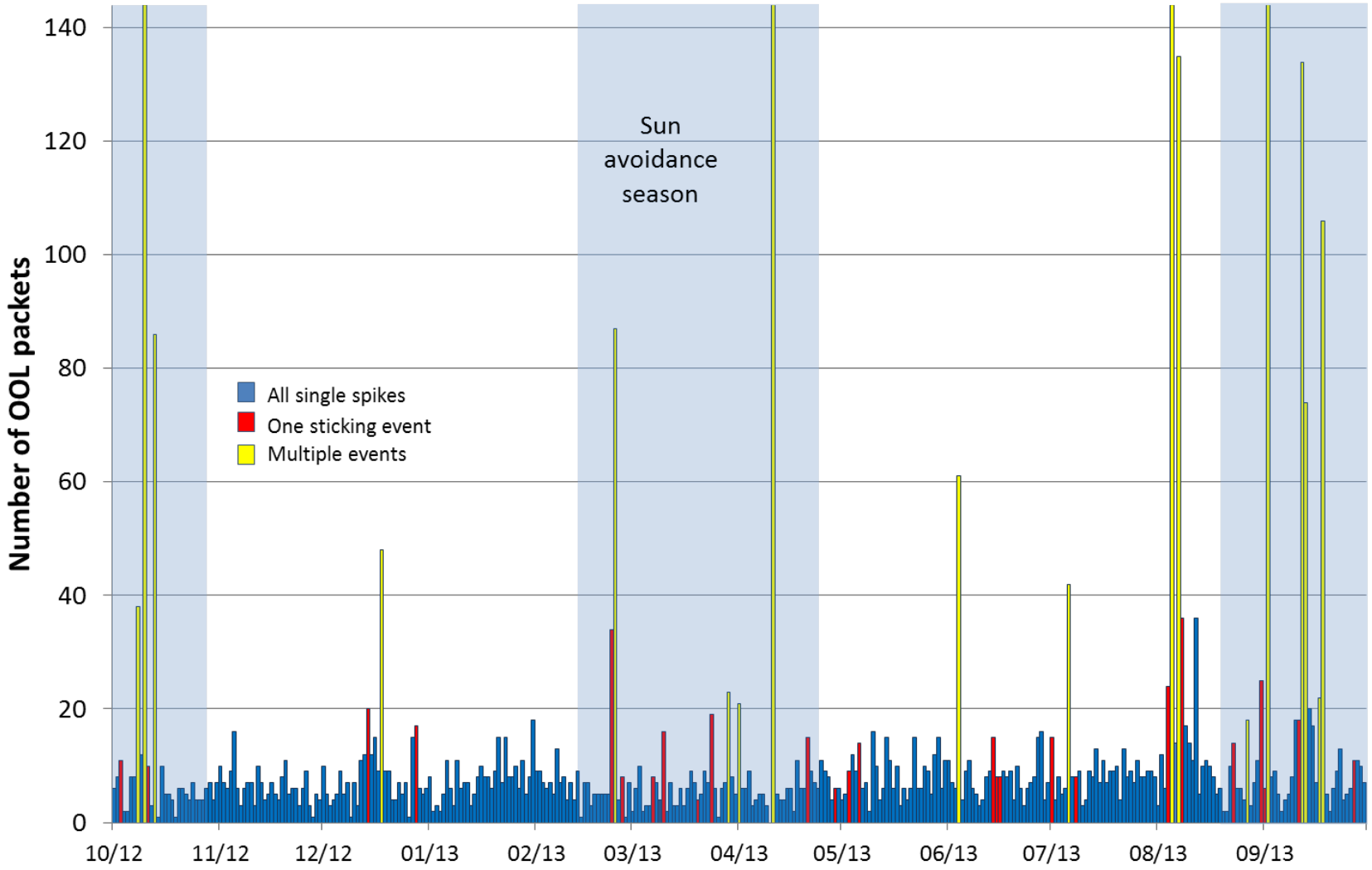
Daily GVMPERR OOL on GERB-1 Despin Mirror, 2012-13



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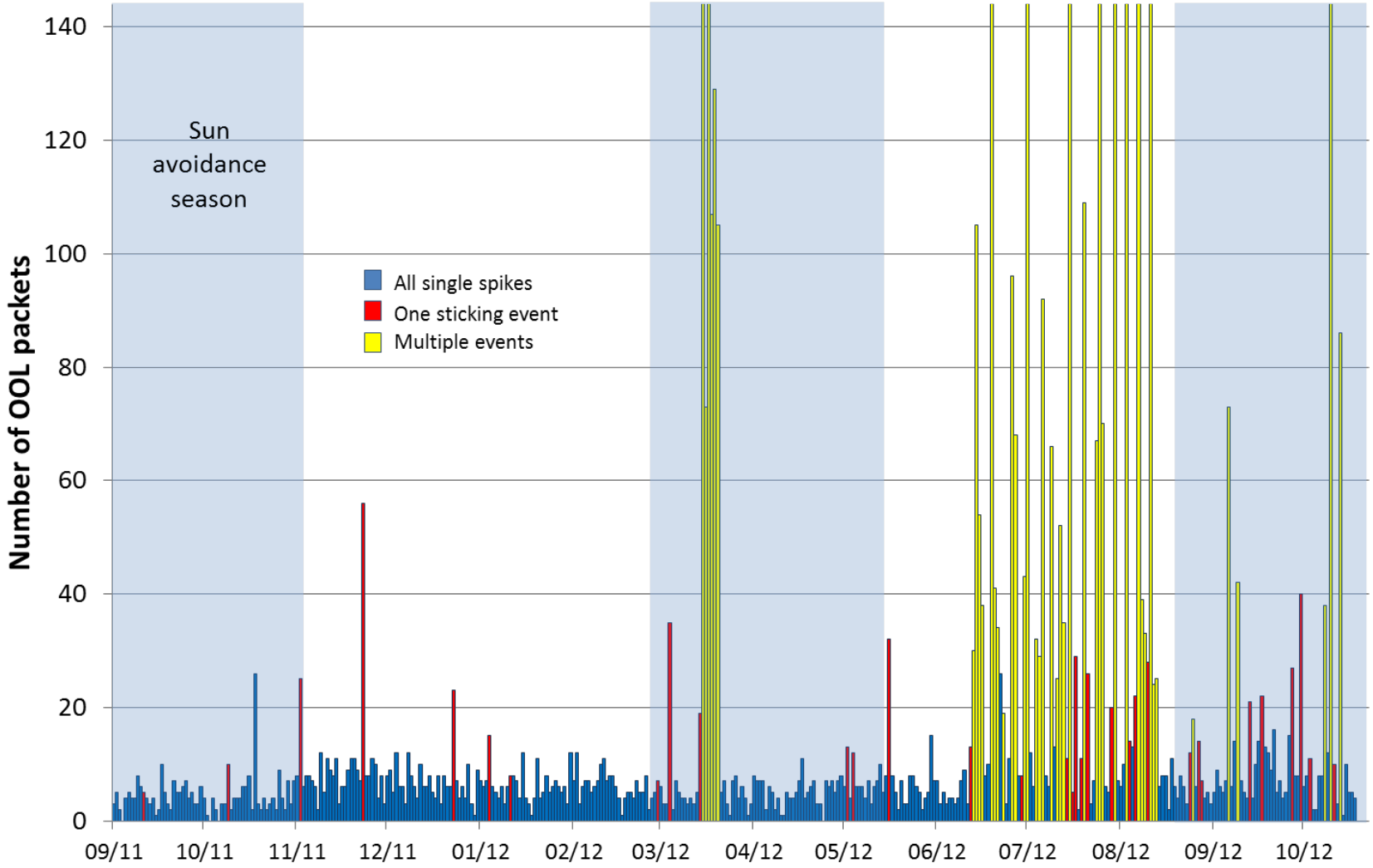
Daily GVMPERR OOL on GERB-1 Despin Mirror, 2011-12



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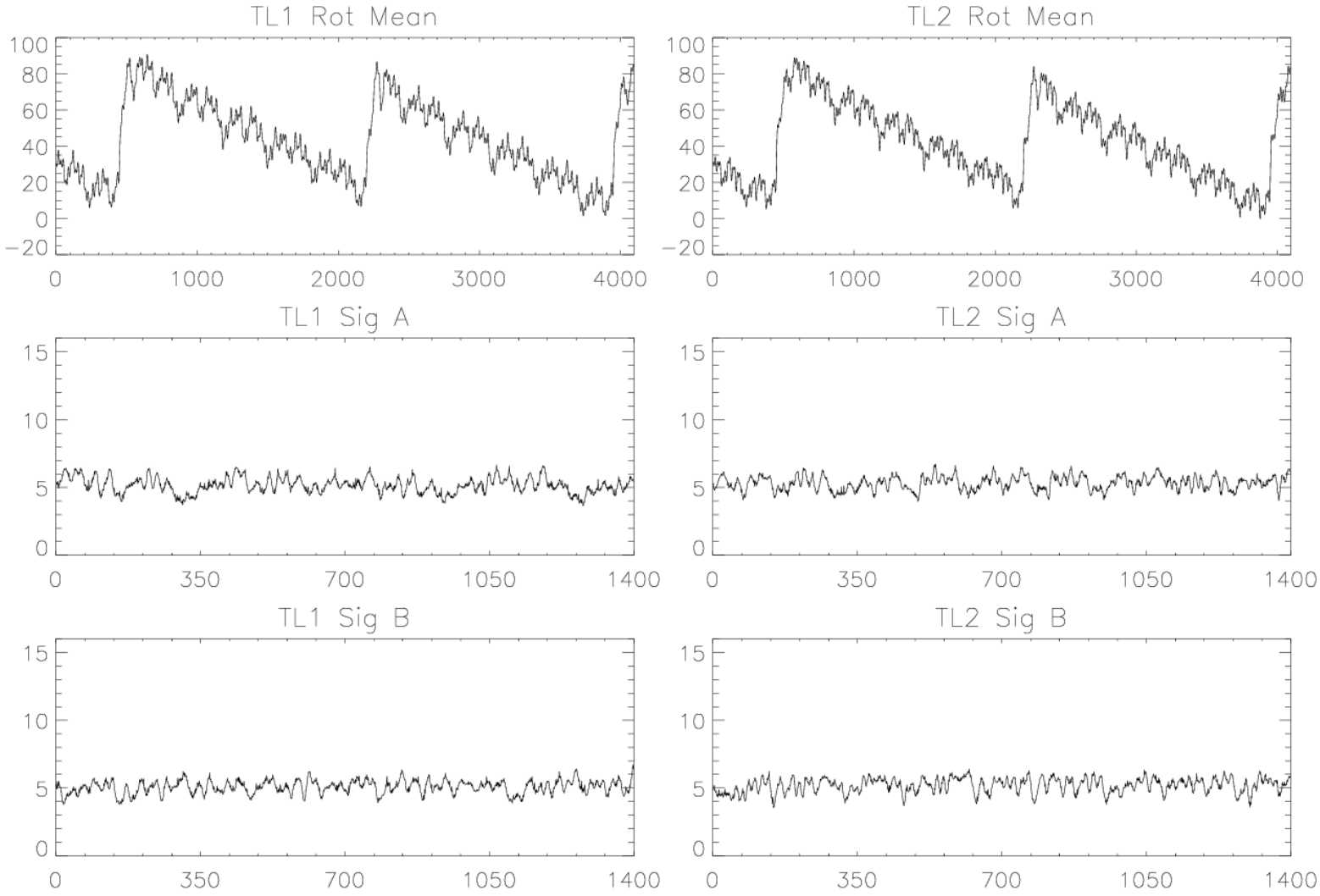
Torque Level Test on GERB-1, 5th August 2014



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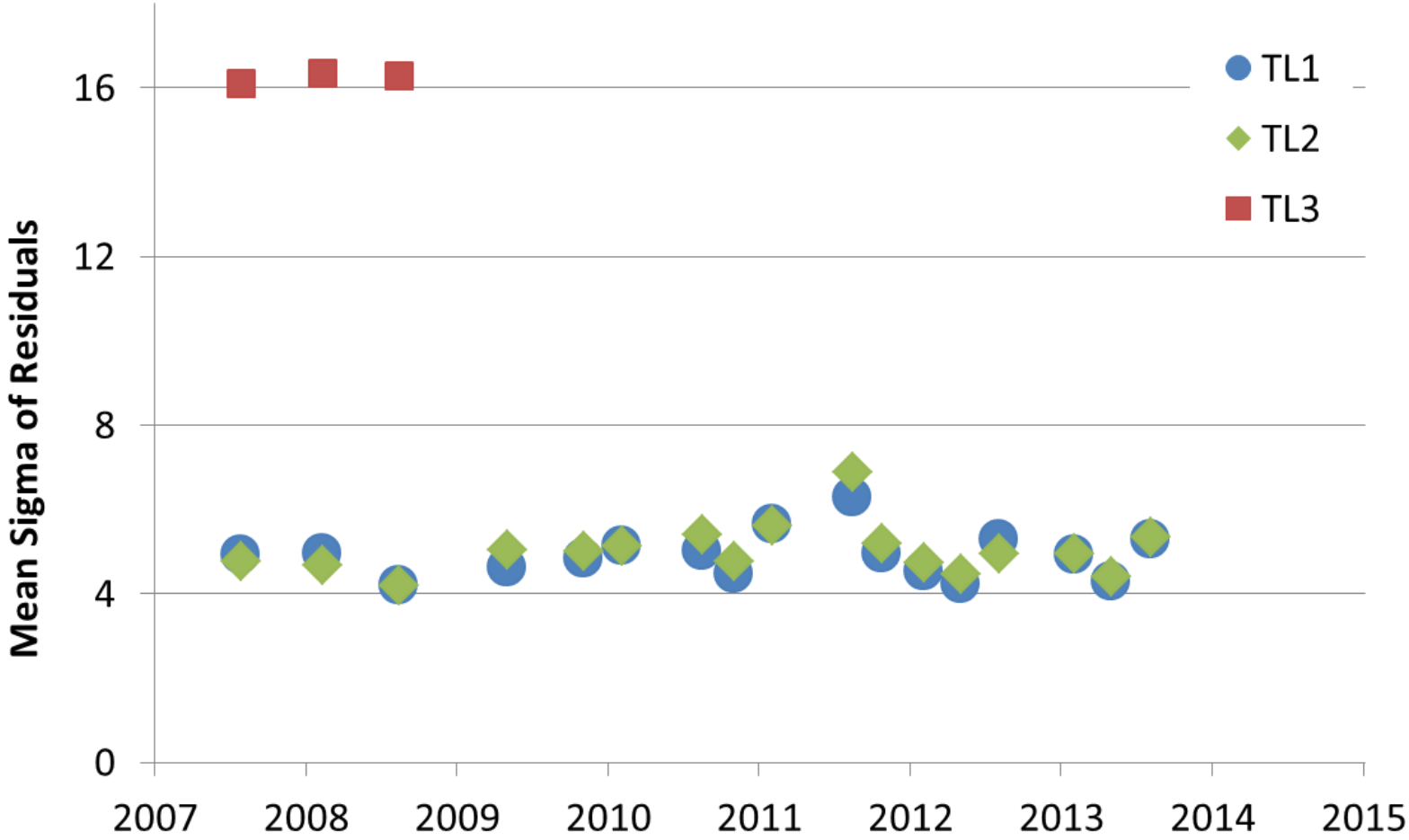
Torque Level Tests on GERB-1 DSM



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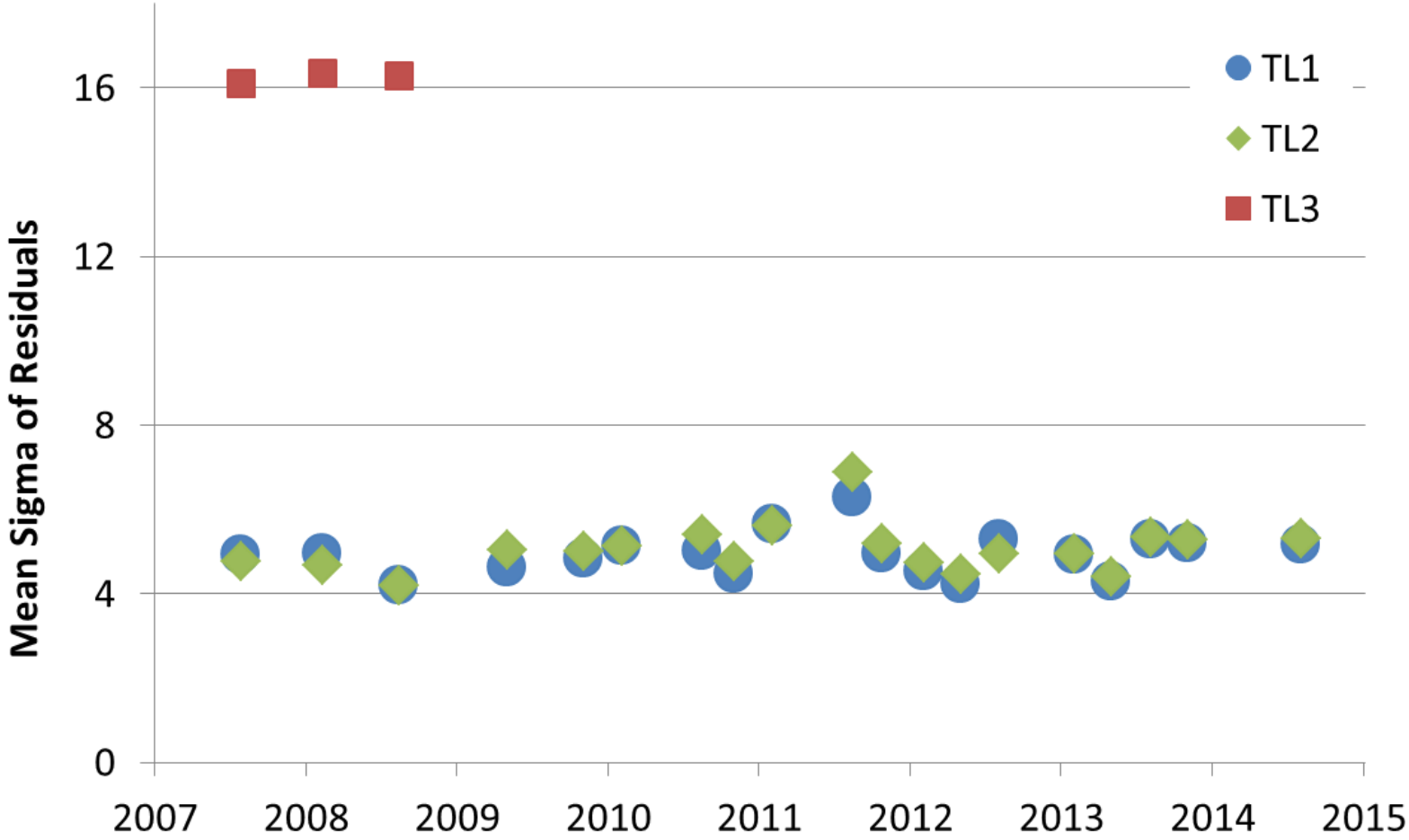
Torque Level Tests on GERB-1 DSM



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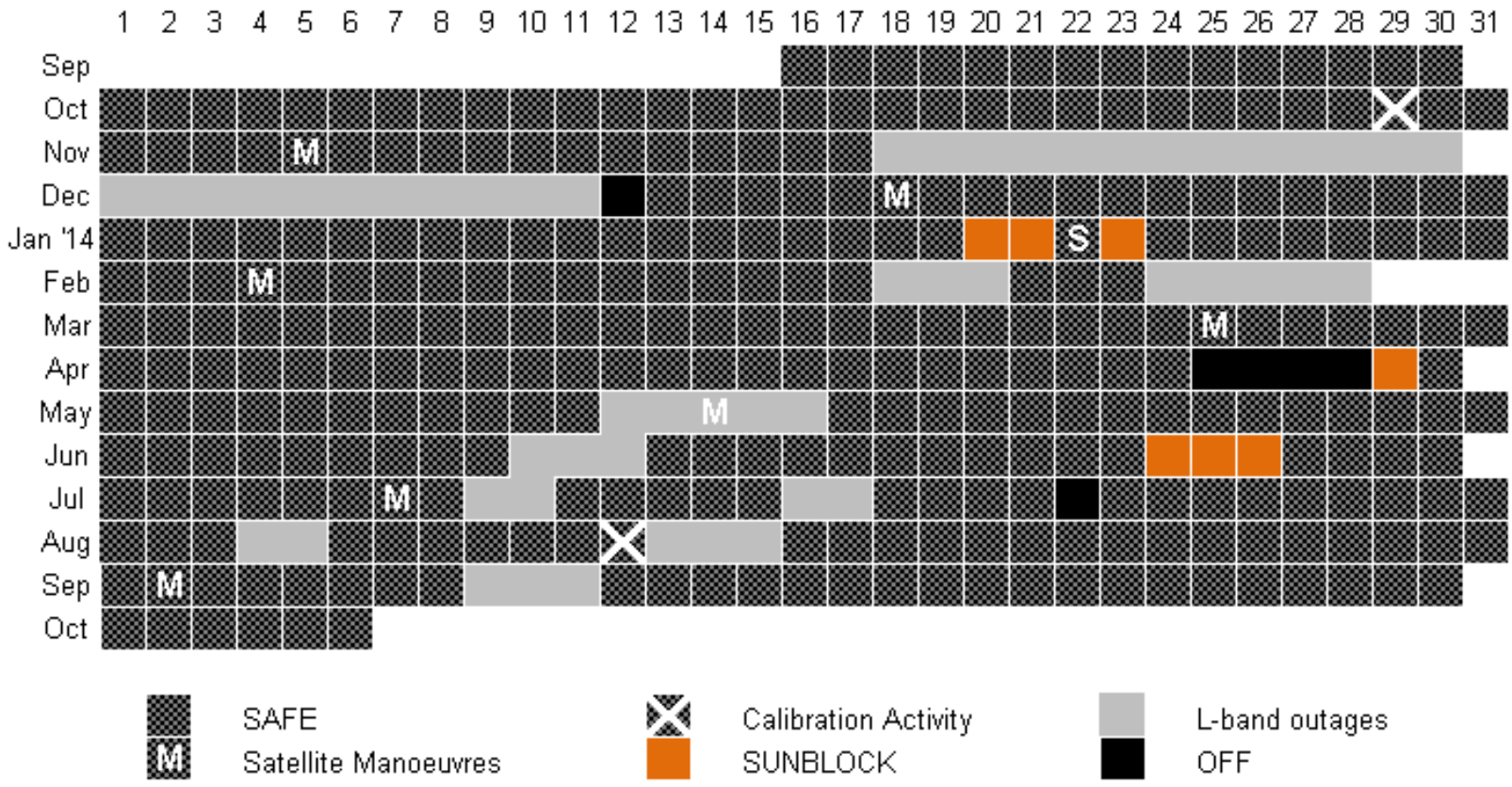
GERB-2 Operations since GIST 33



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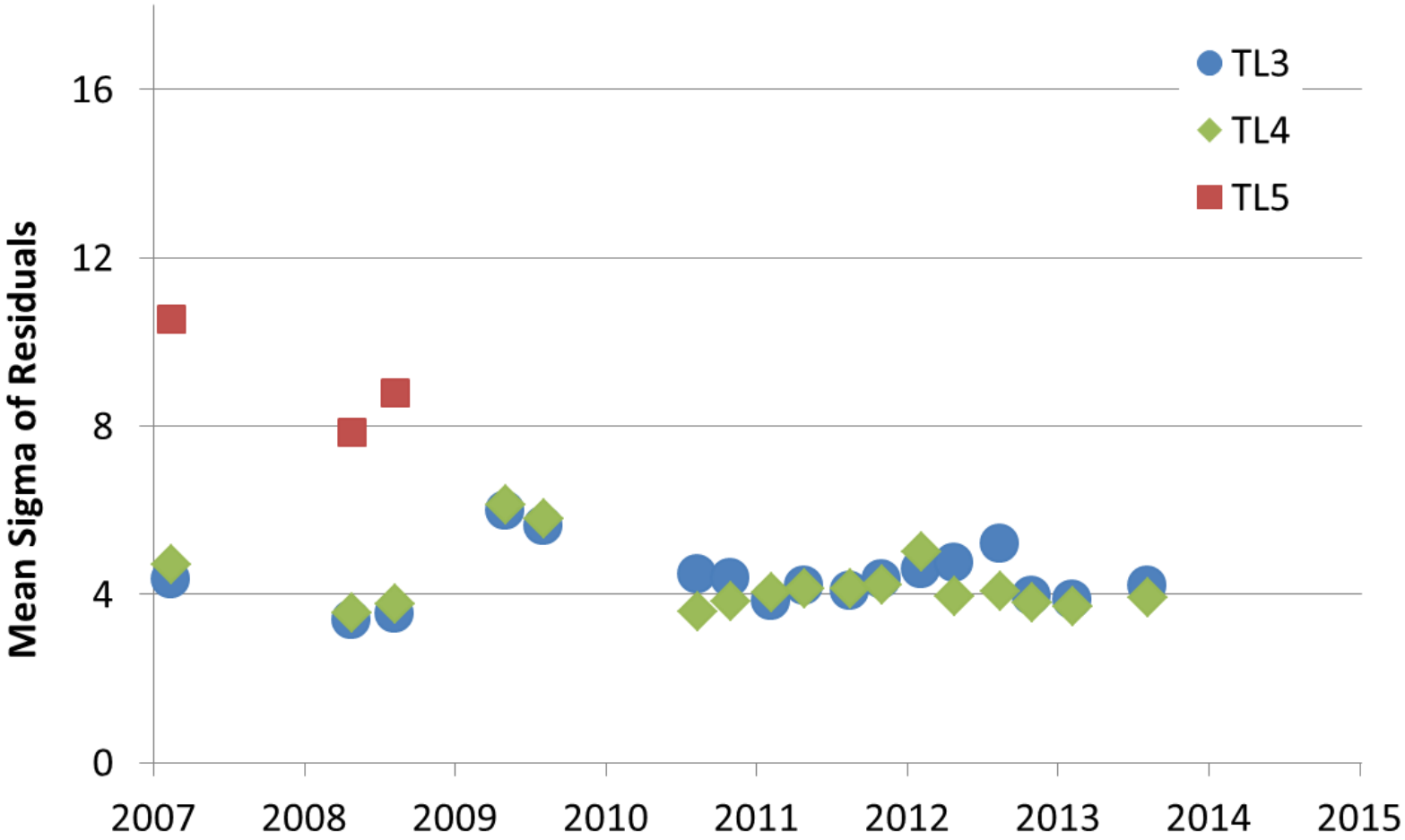
Torque Level Tests on GERB-2 DSM



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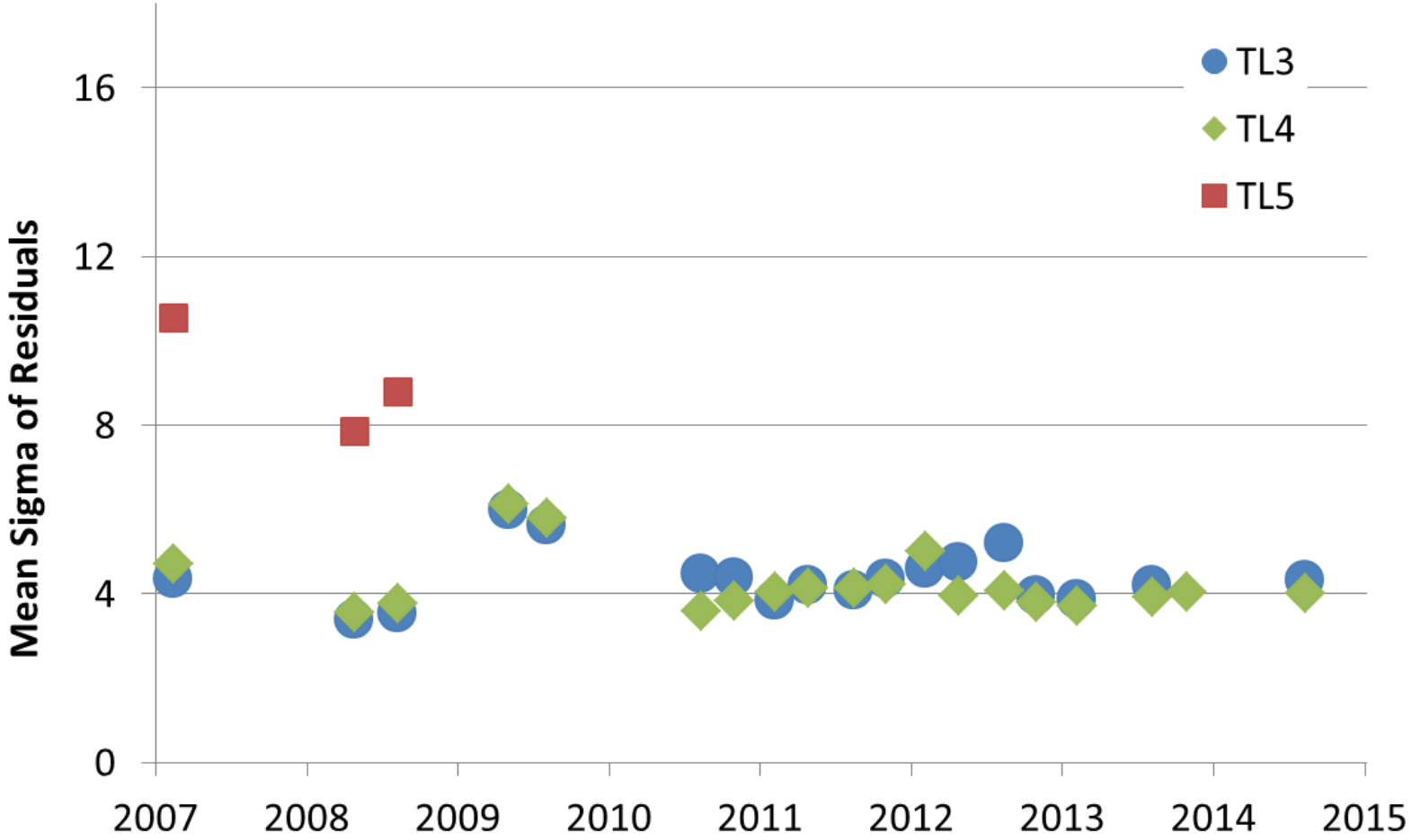
Torque Level Tests on GERB-2 DSM



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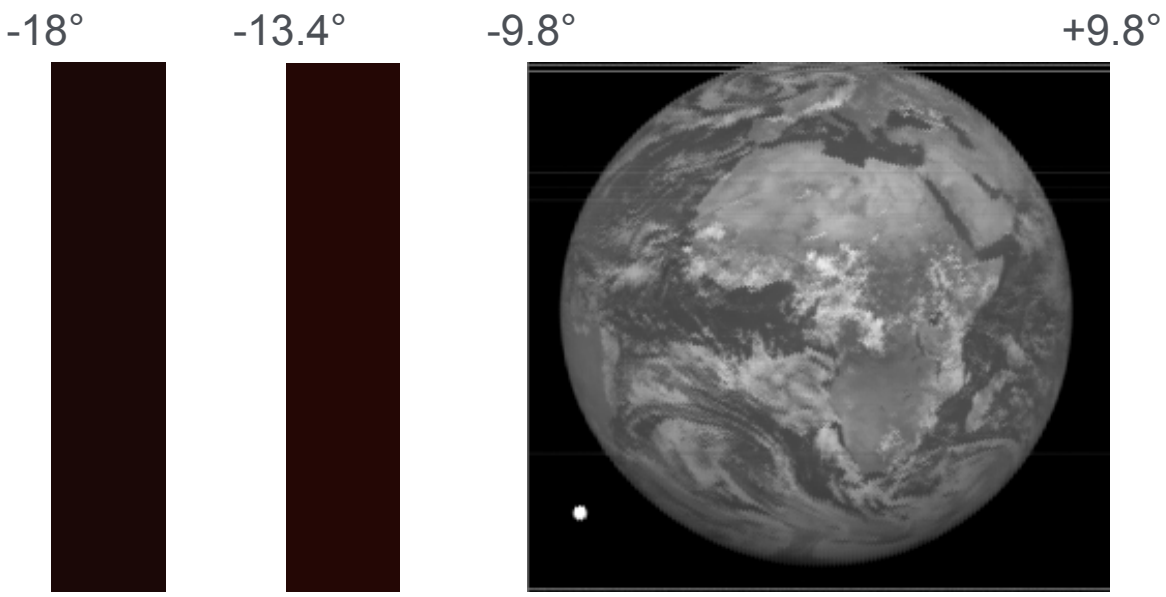
Lunar Observations



Moon not frozen by despin mirror, moves west to east as columns scanned.

SW scans observed in deep space window beginning 18° from NORMAL image center.

TOTAL scans begin 13.4° from NORMAL image center, moon observed over ~10 mins thus three images in each region.

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Lunar Images

GERB1 Feb 1st 2010 SW channel lunar images

GERB2
Apr 30th
2012

GERB1
Nov 6th
2011

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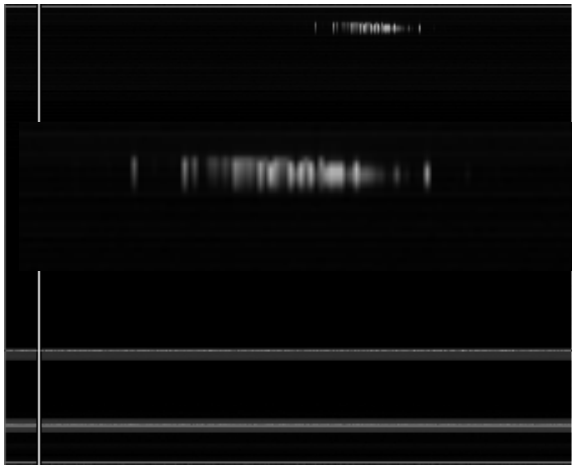
Lunar Images

GERB1 Feb 1st 2010 SW channel lunar images

GERB2 Apr 30th 2012



GERB1 Nov 6th 2011

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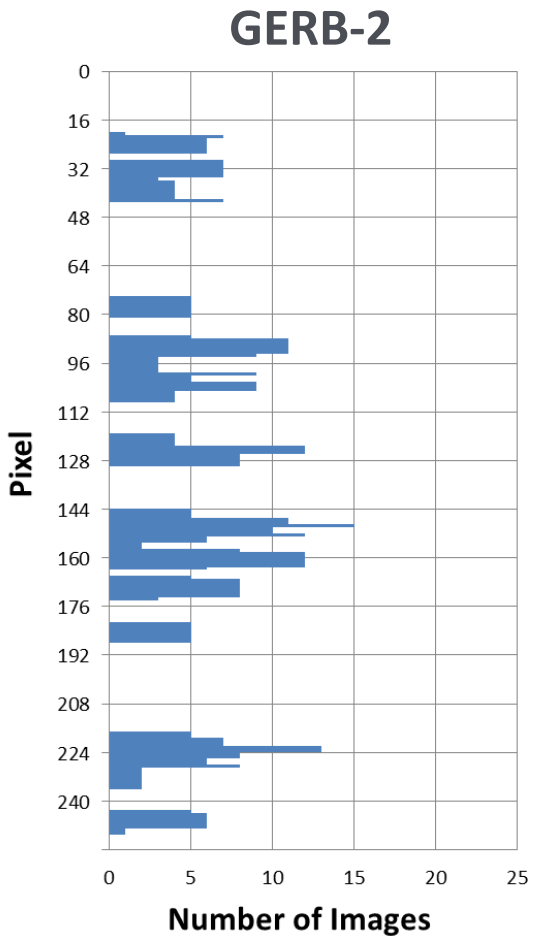
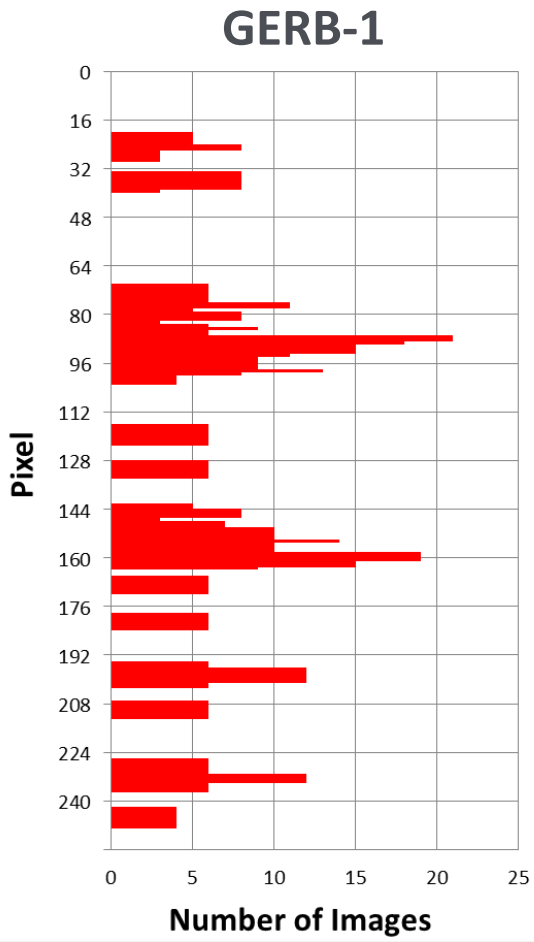
Lunar Observations by Pixel





GERB1 - 52% pixels
GERB2 - 49% pixels

Lunar illumination
0.84±0.10
max 0.98, min 0.51

Not separated for:
Channel
Scan Direction

Does exclude partial images.

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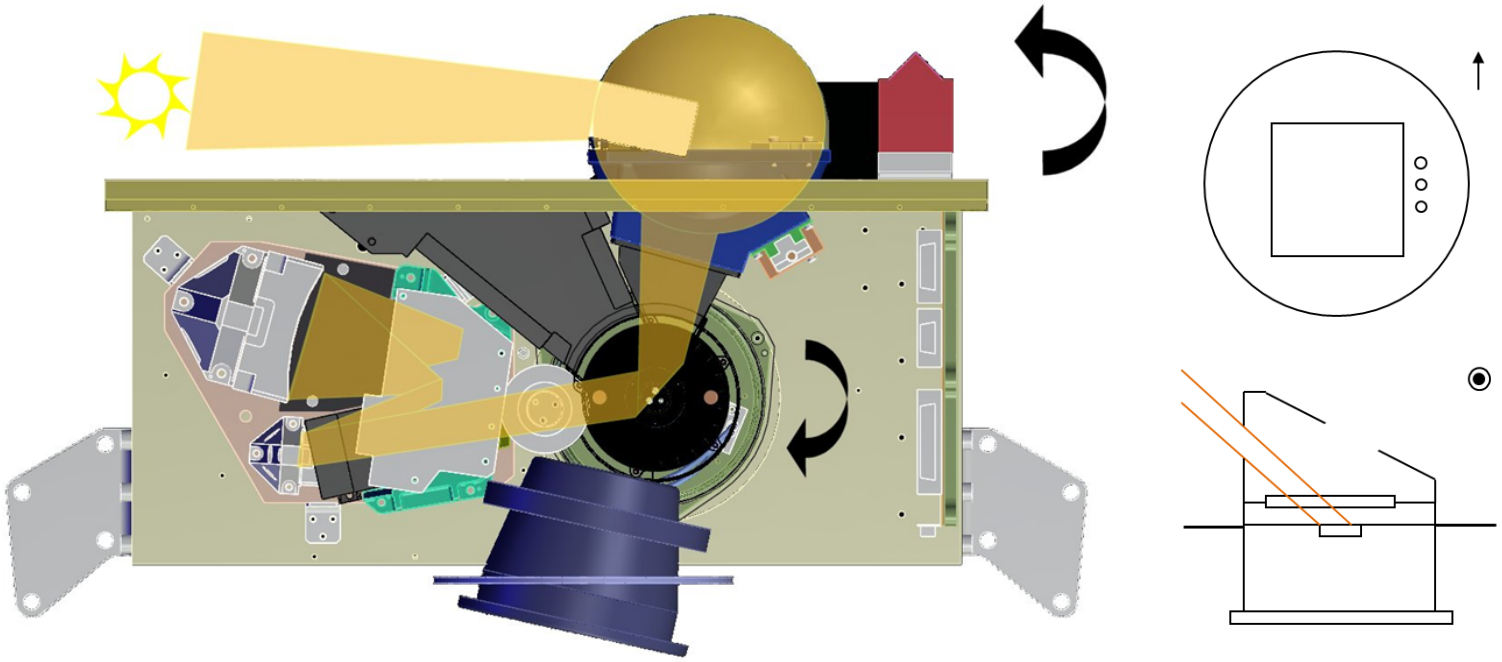
Calmon Photodiodes



Diode	Material	Range (microns)
A	GaP	0.30 – 0.50
B	Si	0.32 – 1.06
C	InGaAs	0.90 – 1.60

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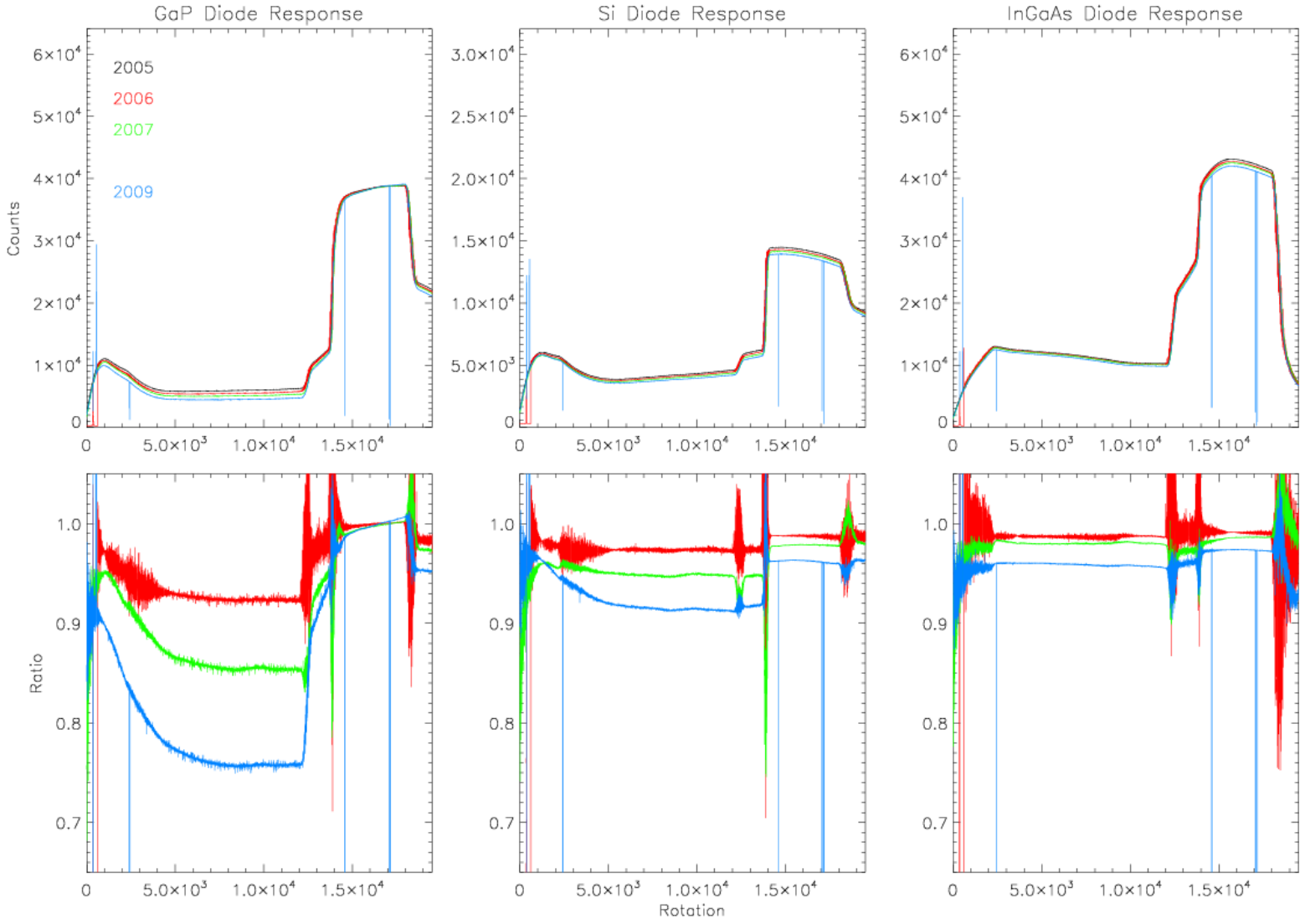
Calmon Photodiodes on GERB-2 over 4 Years



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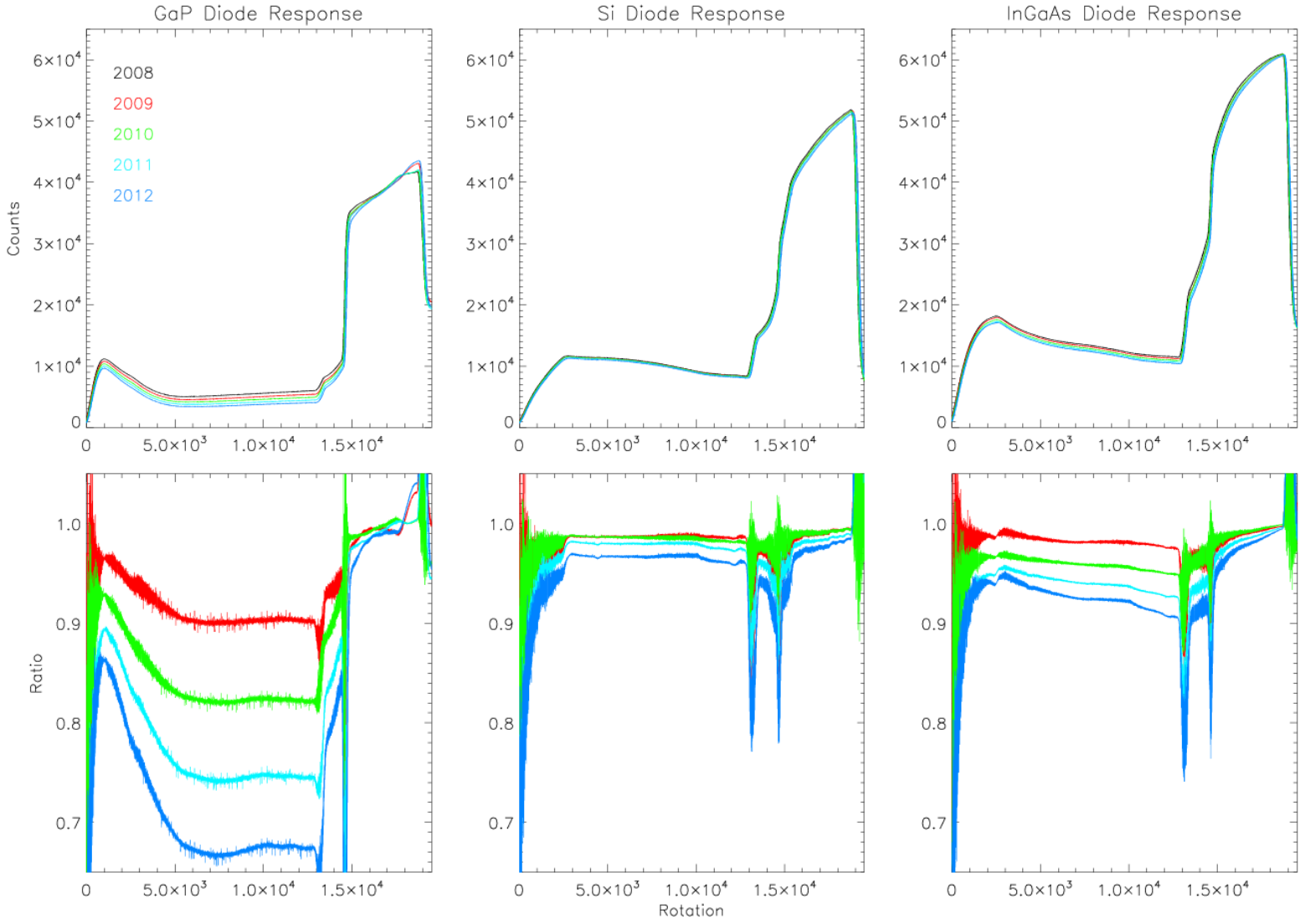
Calmon Photodiodes on GERB-1 over 4 Years



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Diode Performance Changes

	GaP		Si		InGaAs	
Year	GERB-1	GERB-2	GERB-1	GERB-2	GERB-1	GERB-2
1	0.991	0.999	0.985	0.988	0.987	0.991
2	0.992	0.997	0.989	0.979	0.990	0.986
3	0.986		0.977		0.980	
4	0.980	0.997	0.965	0.963	0.971	0.974

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Sphere Performance Changes

	GaP		Si		InGaAs	
Year	GERB-1	GERB-2	GERB-1	GERB-2	GERB-1	GERB-2
1	0.902	0.924	0.988	0.974	0.982	0.987
2	0.822	0.855	0.986	0.948	0.958	0.981
3	0.744		0.980		0.939	
4	0.671	0.758	0.968	0.914	0.924	0.958

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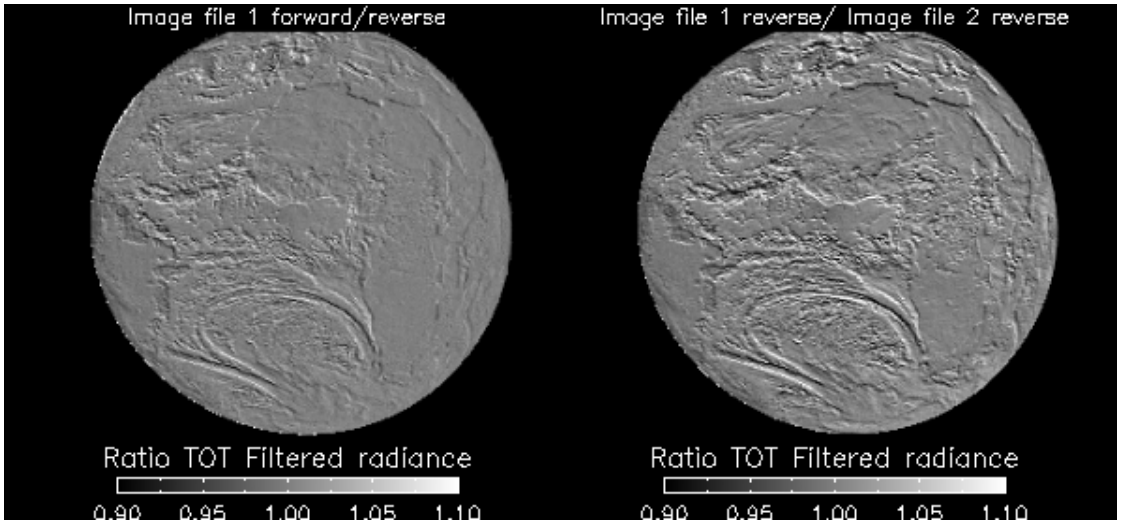
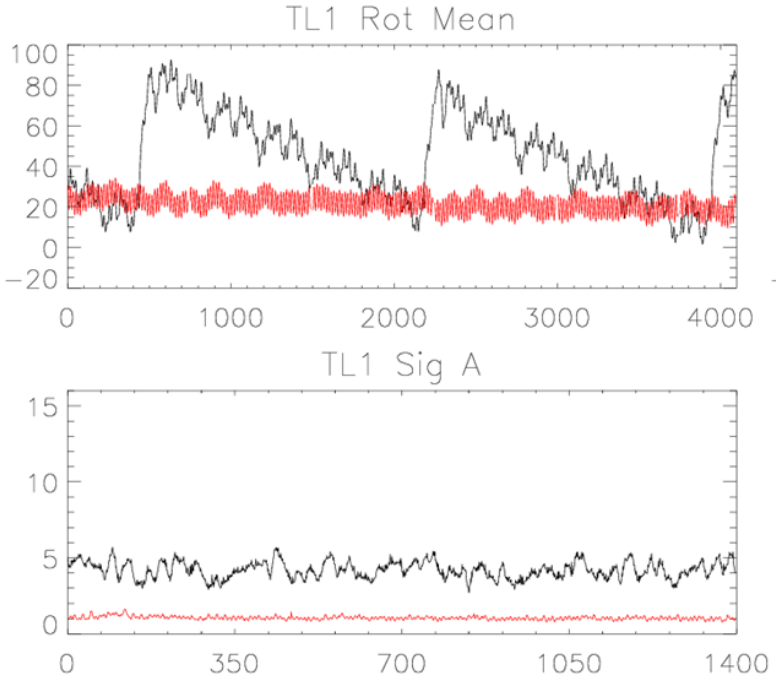
GERB-3 Commissioning and Early Operations

GERB-3 successfully completed functional and calibration commissioning in during August 2012.

The early operations showed a significant improvement to the pointing accuracy of the despin mirror based on the new drive hardware running three nested control loops, position, velocity and torque.





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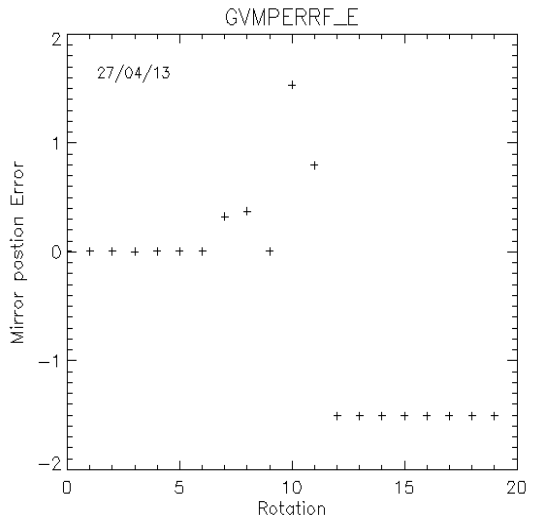
Incident #51

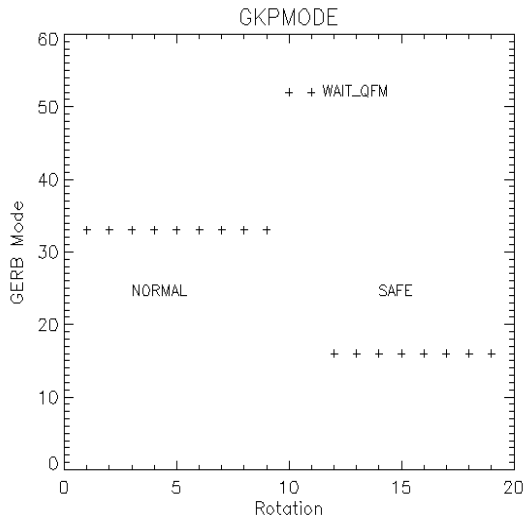
27th April 2013 at 05:56 (All times UTC) GERB-3 experienced a loss of lock on the DSM which caused an AutoSAFE.

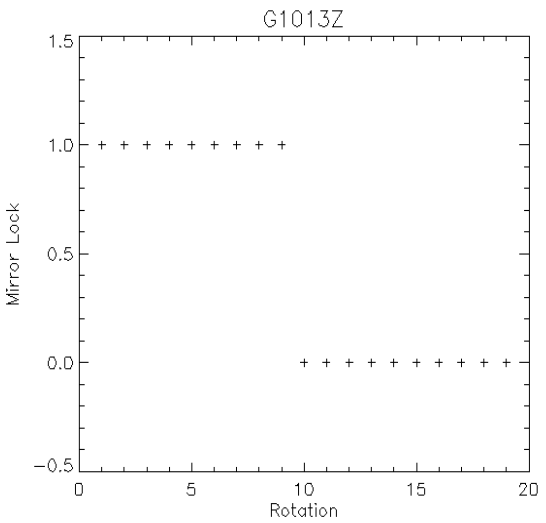
In the next hour GERB-3 periodically exceeded a warning limit on instrument current (G1015Z, 1040 mA) and was switched off at 06:55.

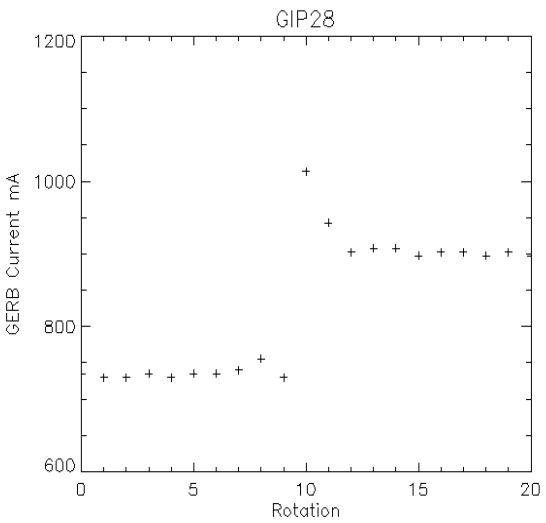
The instrument was recovered to SAFE mode at 10:30 on the 27th.

Subsequent commanding to NORMAL mode failed to achieve mirror lock in SUNBLOCK on two instances (29th April, 2nd May.) Each time the instrument was returned to SAFE and the DSM disabled.









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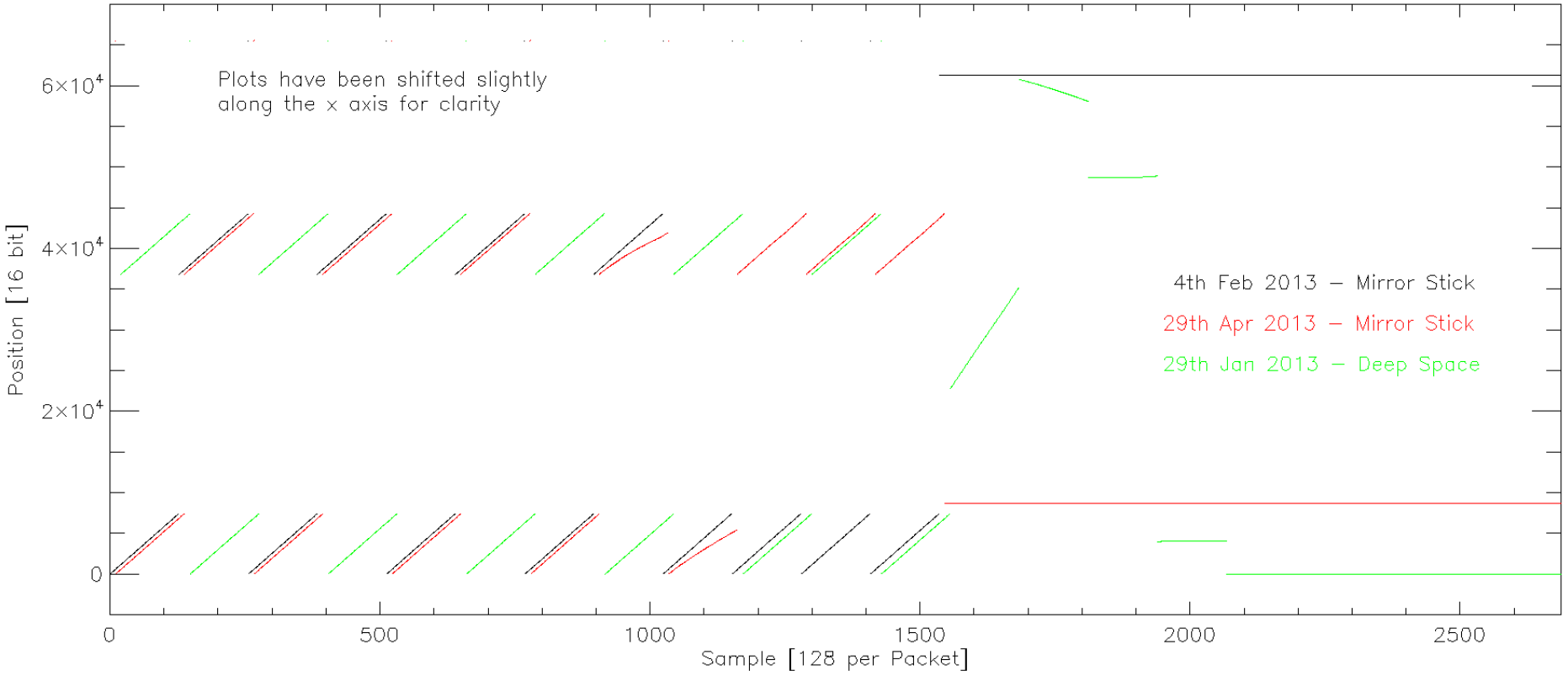
Comparison of Mirror FIFO data

128 mirror position values are given by the FIFO for every rotation for the Earthview regions.
The mirror is driven successfully to position zero in the case of the Deep Space threshold violation but for the mirror sticking events no further movement in the DSM is recorded in either case.
In case of mirror anomaly FIFO data is repeated (last two red and three black packets before SAFE) as no new valid mirror data is supplied.



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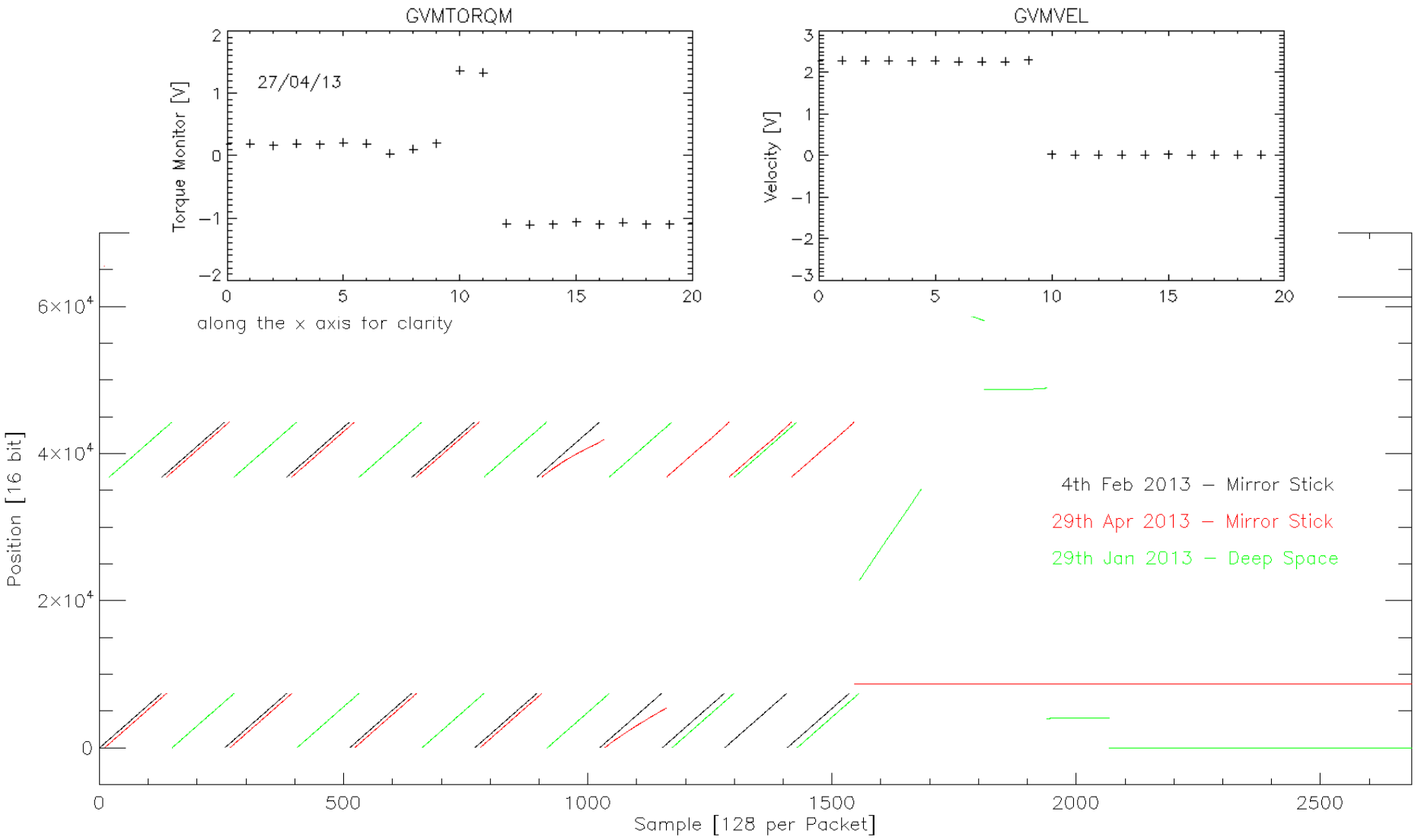
Comparison of Mirror FIFO data



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Recovery Operations I

Date	Test/Operation	Notes	Result	VCS
22nd May	60° steps backwards from 300°	In SAFE mode, drive enabled	Torque reversal between 240° and 180° (response consistent with assumed mirror position between 0° and 60°) no discernible DMS movement	0x4200 Fine, Track, VE2
23rd May	+/-90° from 15° FIFO position	In SAFE mode, drive enabled. 40 mins, 10 minutes per command.	Torque reversal but insignificant DMS movement (1 bit flip)	0x4200 Fine, Track, VE2
28th May	Command to SUNBLOCK	Non standard VC Mode	Small VDEM values, continuous torque reversal (nominal for 0x7200.) No discernable DSM movement.	0x7200 Coarse, Slew, VE2
29th May	Command to SUNBLOCK	New VC mode	Full scale VDEM value oscillation, continuous torque reversal (nominal for 0x6200.) No discernable DSM movement.	0x6200 Coarse, Track, VE2
5th June	Full rotation at 7.2° steps	DSM disabled. Test position error response.	Drive system position error shows system apparent position between 36° and 43.2°. Consistent with backward sweep result.	0x1200 Fine, Slew, VE2

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Recovery Operations II

Date	Test/Operation	Notes	Result	VCS
12th June	Fine scan from 33.975° to 40.05°, power cycle, repeat full scan 360° @ 7.2°	DSM disabled. Test position error response.	Apparent position 36.82°. Second test failed due to lack of timing board initialization.	0x1200 Fine, Slew, VE2
13th June	Repeat 360° @ 7.2°	Command to SUNBLOCK then back to SAFE to initialise timing board.	Control system apparent position unchanged within digitisation limit.	0x1200 Fine, Slew, VE2
17th June	+5º/0/-5º/0 x10 @2s and 5s intervals	Rapid command of discrete DSM positions around apparent position.	Torque reversal seen but no lock or significant movement.	0x4200 Fine, Track, VE2
18th July	Constant Rotation	New VC states which omits torque loop used.	Constant rotation not achieved.	0x4201-4207
18th July	'Kick' Test	Exploit behaviour seen in ground testing. High torque generated by switching power relay to DSM last in SUNBLOCK.	GERB-3 fails to achieve lock in SUNBLOCK when power restored.	0x4000 Fine, Track

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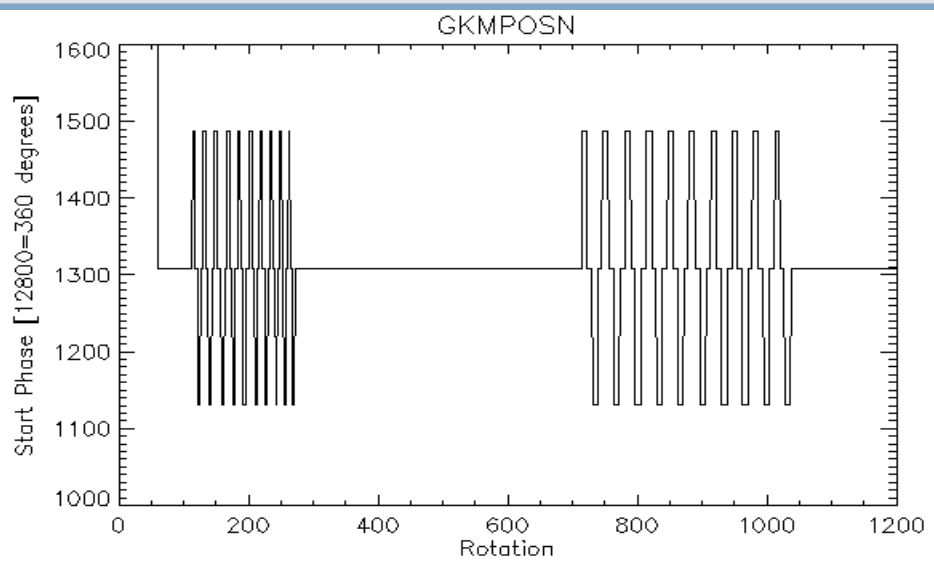
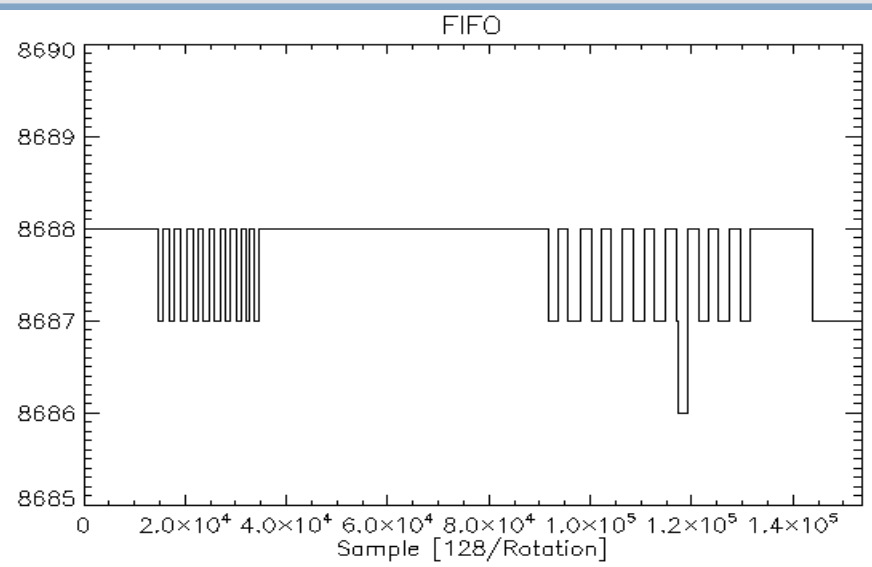
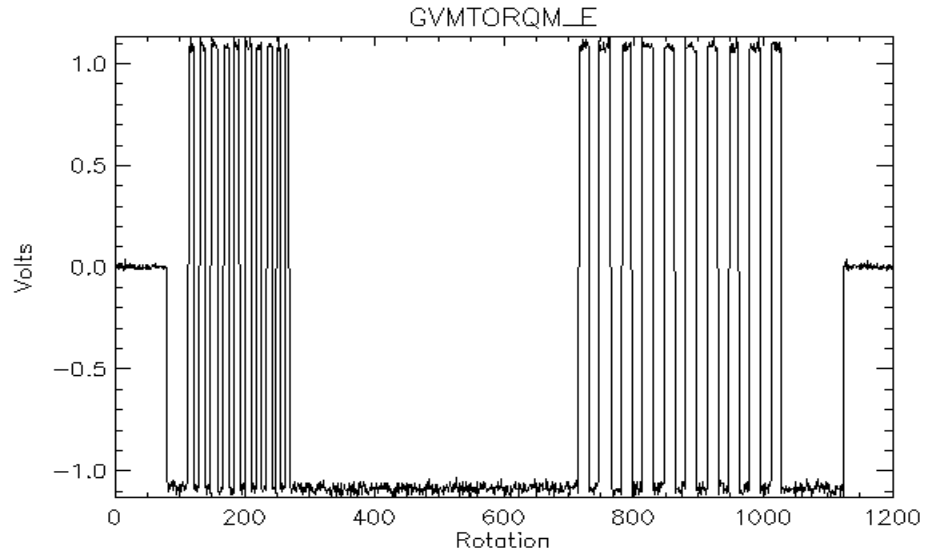
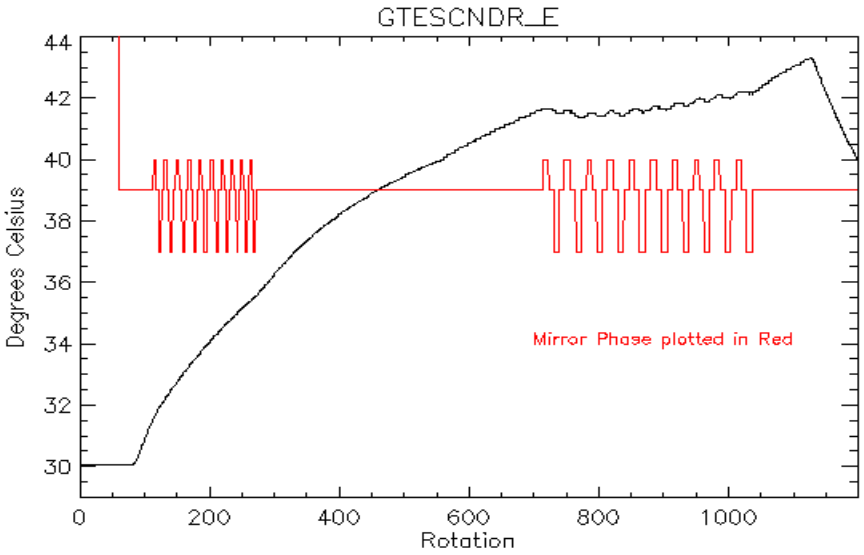
Mirror Pulse over +5/0/-5/0°









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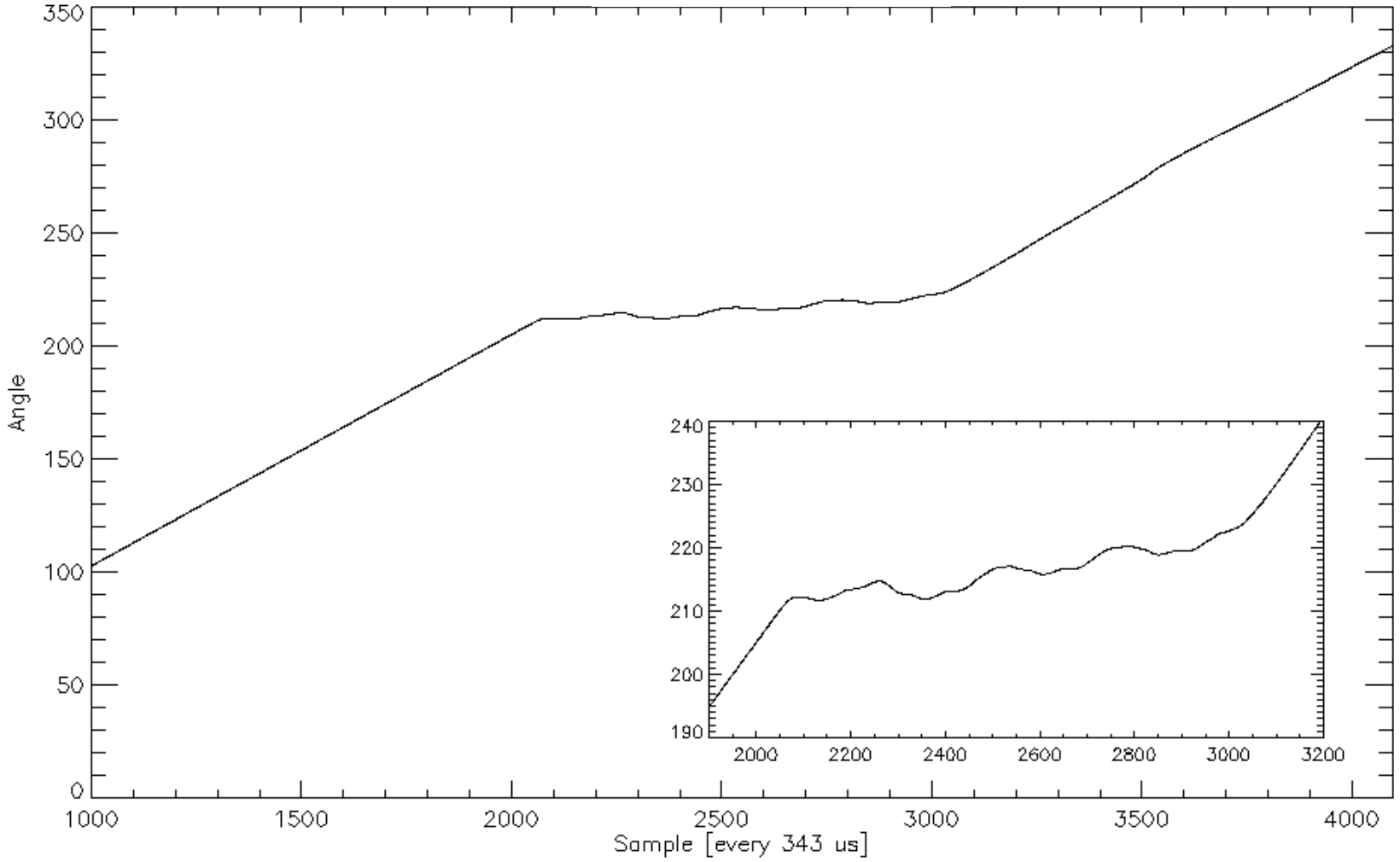
Mirror 'Tapping' on GERB-2, 17th August 2012



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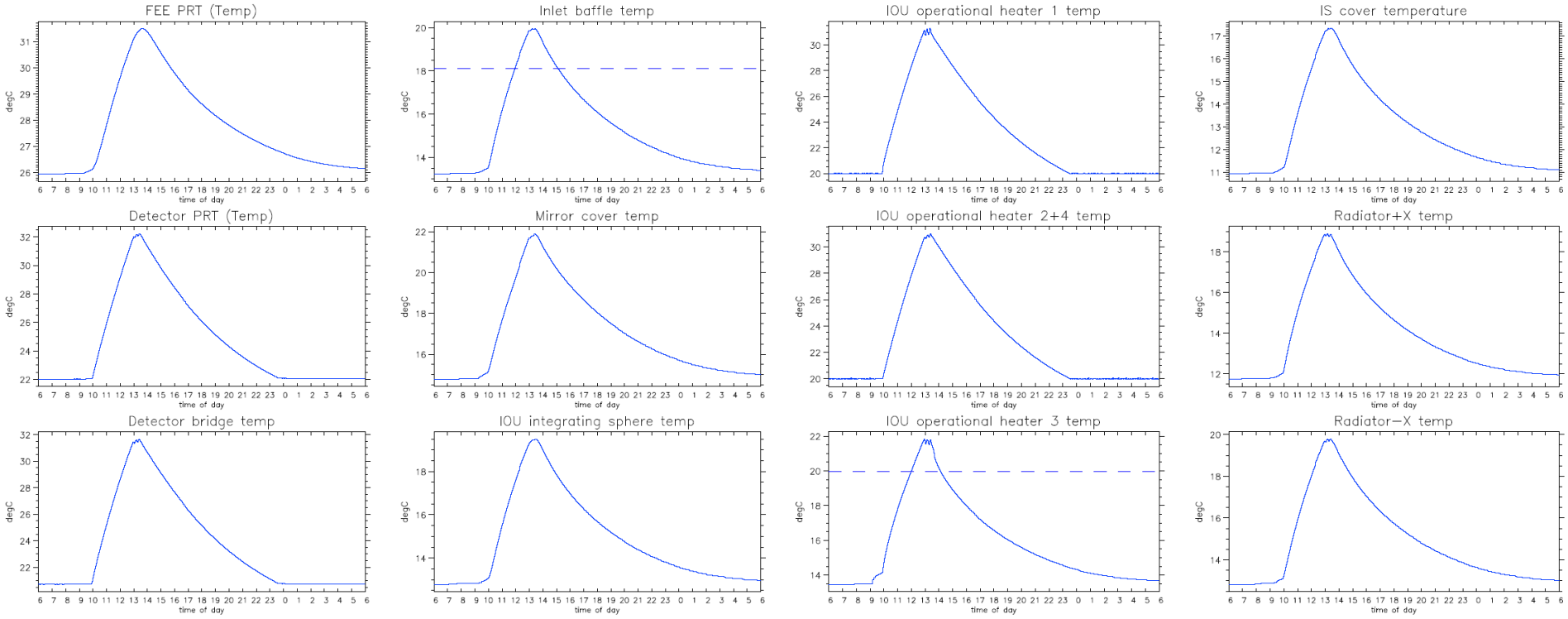
Regular and Thermal Tests

A regular test of the GERB-3 bearing was attempted twice a week based on the example of the jam on ATSR which was resolved after its mirror was commanded each overpass.

Over the course of 6 months (Oct ‘13- Mar ‘14) 31 tests including 6 using the survival heaters to raise the GERB baseplate temperature were attempted.



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GERB-4 Launch, Commissioning and IOS

GERB-4 Launch

- Baseline launch date 2nd July 2014
- Launch possibly as late as the end of October

GERB-4 Commissioning

- If launch is early in July commissioning will run in mid August 2015
- Otherwise commissioning will commence at the end of the 2015 Sun avoidance season

In Orbit Storage

- MSG-4 will got into IOS post commissioning (~Launch+5 months)
- During IOS GERB-4 will be activated for 3 days every 6 months (early Feb, early Aug) for mechanism conditioning in NORMAL mode and calibration scans

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END

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Introduction

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GERB-4 Control Board Modifications

Open-Loop startup mode

- Constant torque, no dependence on mirror position feedback
- 8 commandable torque levels, 0 to 340 mN
- Forward or reverse direction
- Slow speed: 3.4 RPM (maximises torque)

Improvements in closed-loop mode (normal operation)

- 2 torque levels: 50%, 100%
- Anti-windup circuit

  Improves operation through stiction events by avoiding velocity loop saturation.

  This should speed up return to normal mirror rotation.

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Other GERB-1 MSG-2 Issues

Well…

SEVIRI on MSG-1 in RSS most of the time so processing headache

Give RSS/FES schedule

Anything else?

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February GERB-3 DSM Incident

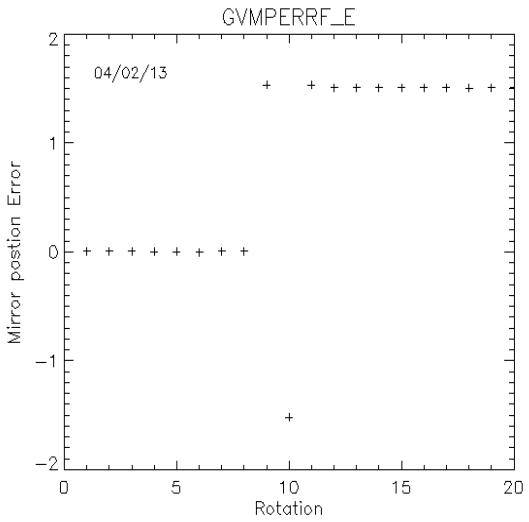
A similar event has occurred once before on GERB-3 at 19:28 on 4th February.

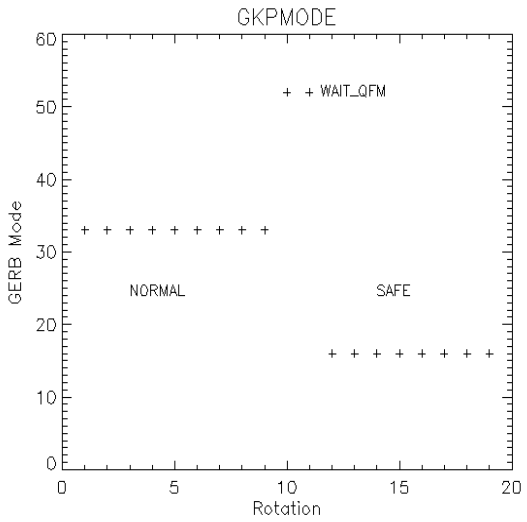
After two OOL packets on GVMPERRF the hardware in-lock flag was deasserted and the AutoSAFE transition began.

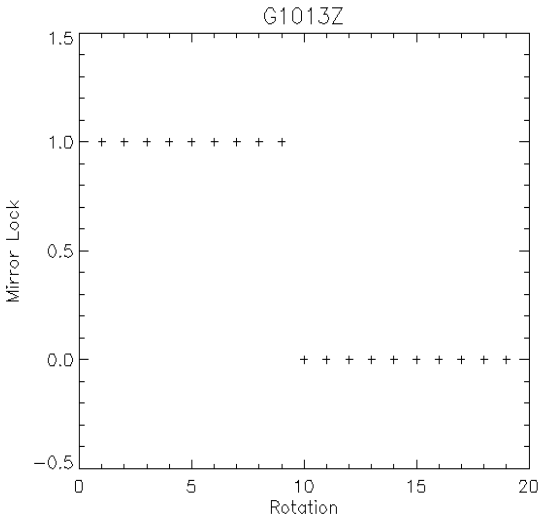
In this case the instrument also raised alarms on the inner, high current limits overnight as the mirror attempted to drive to its zero position.

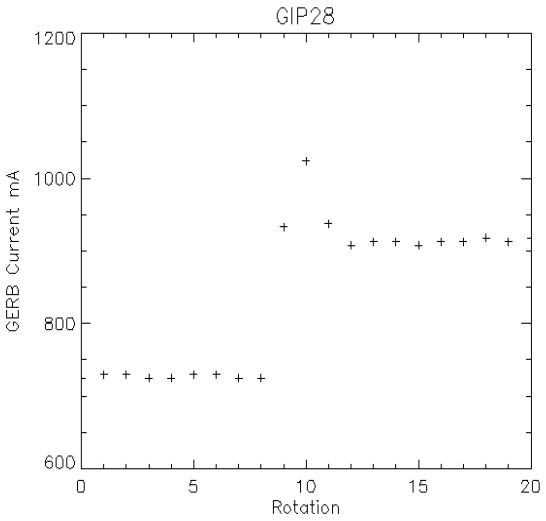
The instrument was power cycled at 09:00 on the 5th of February and successfully recovered to SUNBLOCK at 15:00 on the 6th and to NORMAL at 11:00 on the 7th.

The instrument remained in NORMAL until the 13th of February when it was commanded to SAFE for Sun avoidance.









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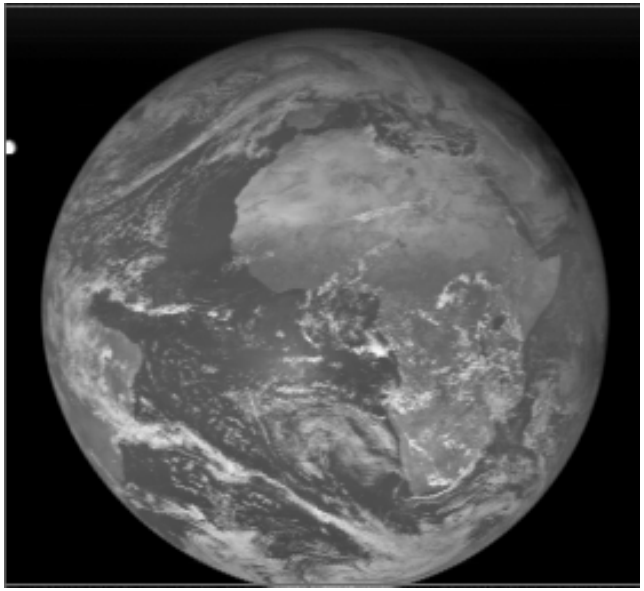
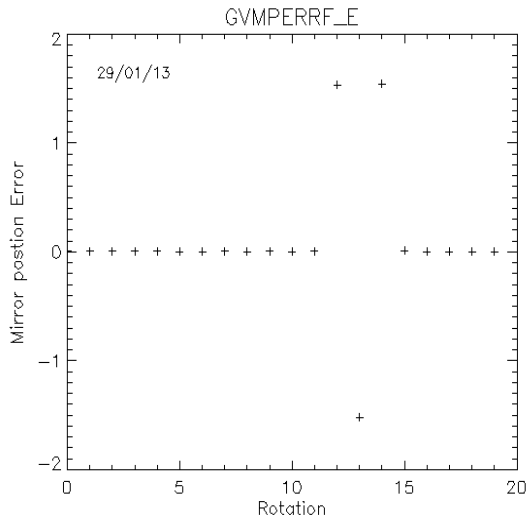
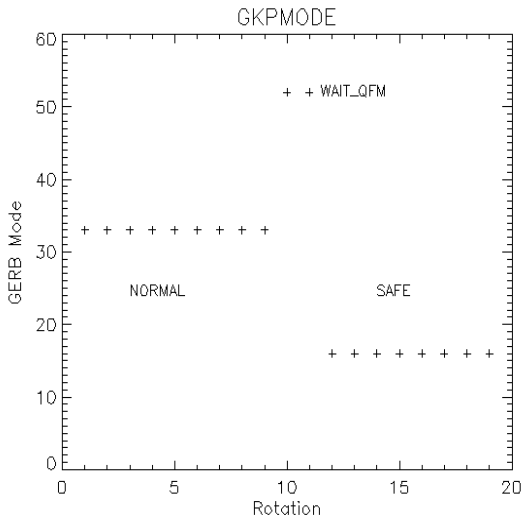
AutoSAFEs on Deep Space Test

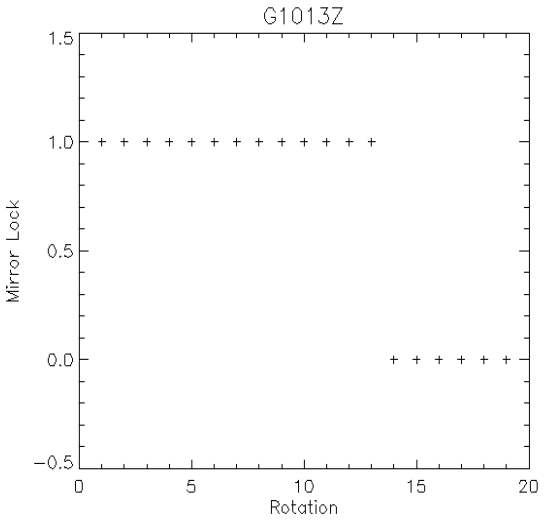
GERB-3 has experienced three more AutoSAFE incidents since launch caused by high signal tripping the deep space column checks.

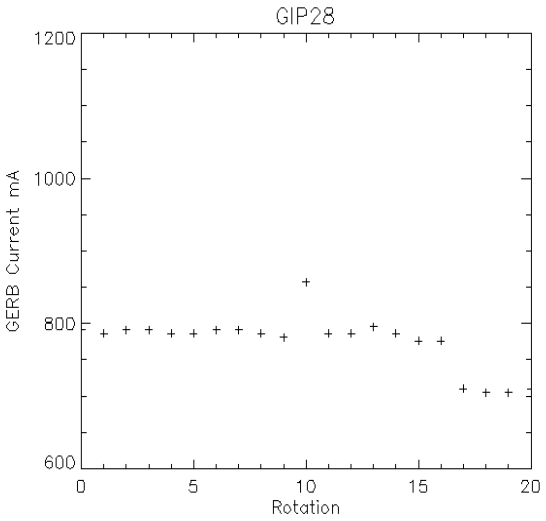
In these cases no current limits are violated in SAFE mode after the event.











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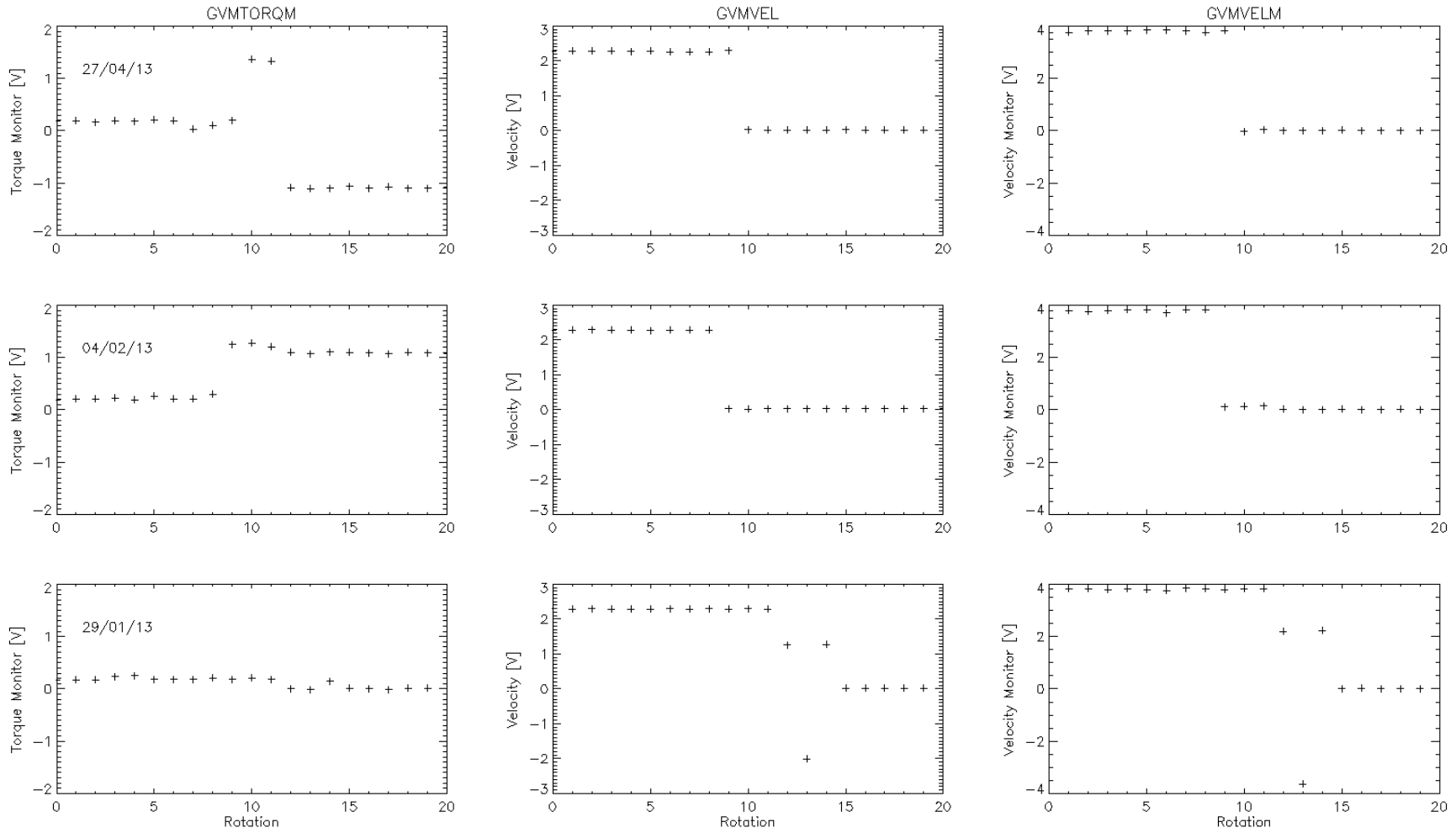
AutoSAFE Incidents Compared



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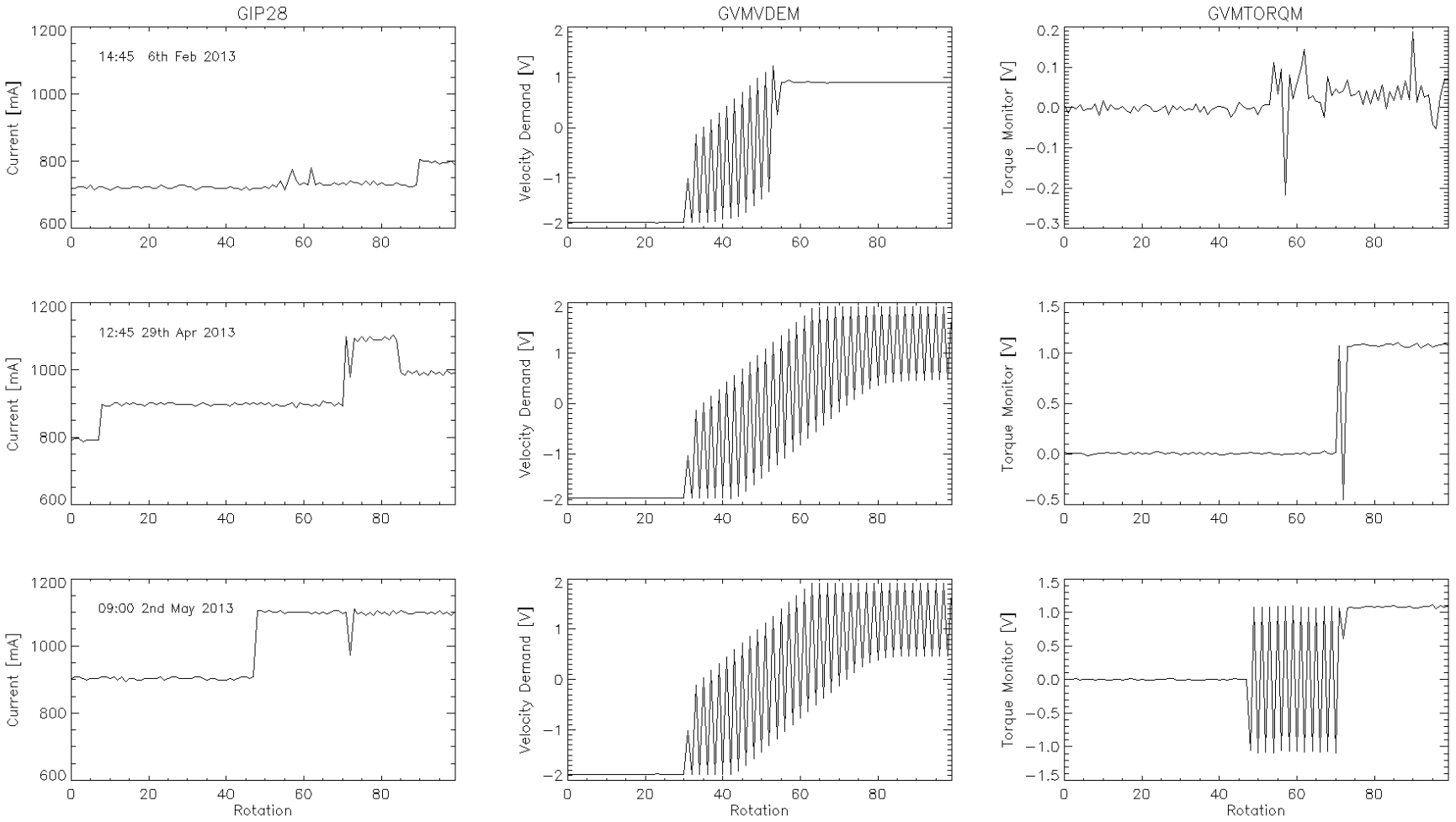
Initial Restart Attempts – Command to SUNBLOCK



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Comparison of the Early Performance of GERB Bearings

The GERB-3 bearing ran for 106 days in NORMAL mode before the second sticking event. Comparing position errors recorded on GERB-3 with earlier instruments over the same period it can be seen that the GERB-3 bearing falls between the rough early running on GERB-1 and the smooth running GERB-2.

Events from a known anomaly on GERB-1 due to mispointing after a stationary mode were neglected.

	Incidents	Sticks	First Stick
GERB-1	102	12	Day 1
GERB-2	3	0	-
GERB-3	7	2	Day 95

Incidents are single events, sticking events consist of consecutive packets with DSM performance OOL.

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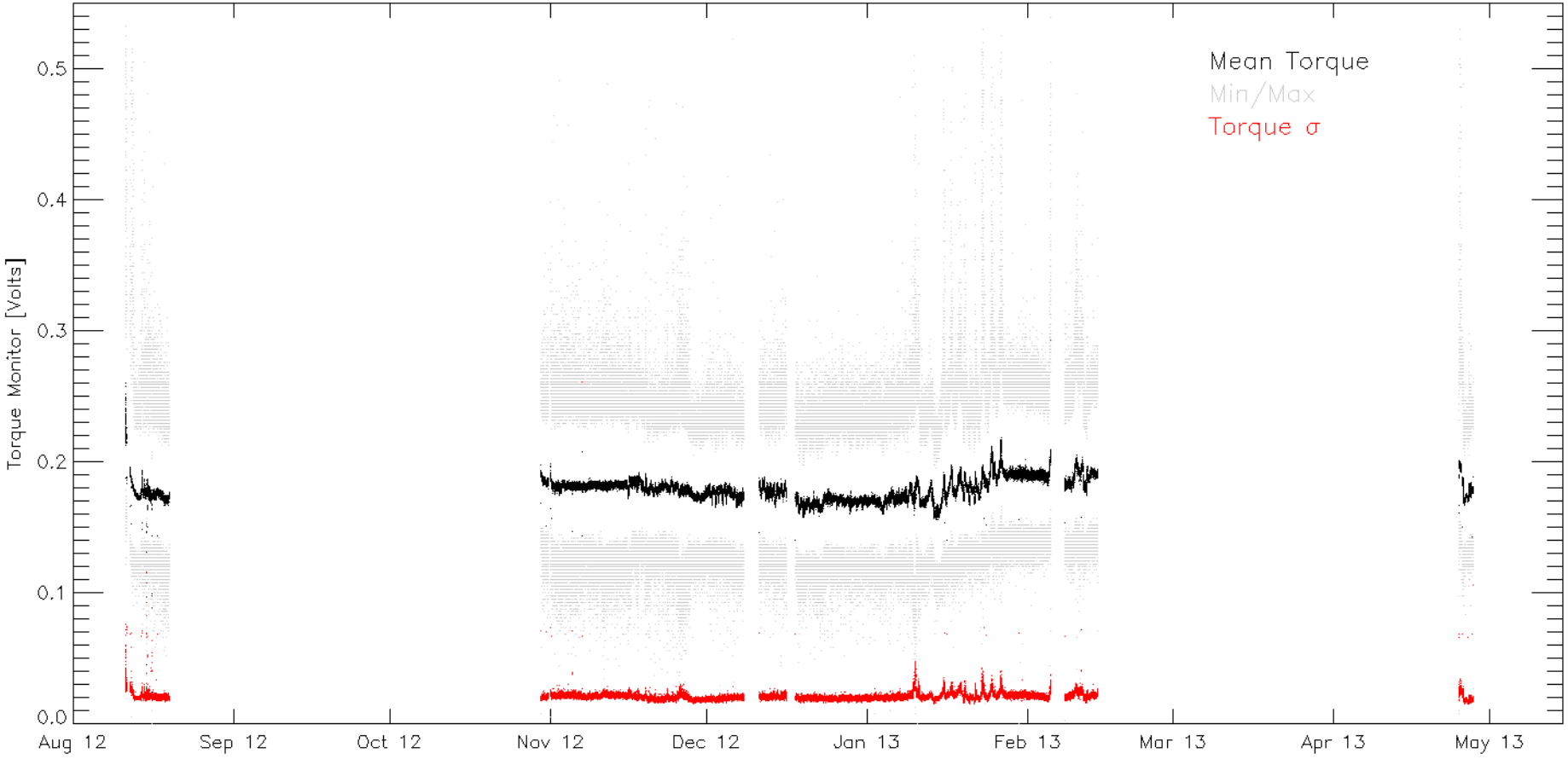
GERB-3 Torque Monitor



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Differences of GERB Drive Systems

The GERB-1/2 DSM drive system consists of a velocity controller with periodic position correction.

In GERB-3 the drive uses a vector control system with three nested loops controlling:

- Position
- Velocity
- Torque

The GERB-3 system adjusts torque applied automatically throughout the rotation to improve the pointing performance of the despin mirror.

The GERB-1/2 system adjusts corrects position once per rotation.

The coarse control is used in acquisition, Fine/ Track is used under nominal conditions (0x4200, 0x4000 & 0x4028.)

Ripple rejection is used to further enhance the pointing accuracy of the DSM.

Bit (15 = MSB)	TM mnemonic	Description
15	-	
14	-	Descan drive enable
13	GSMCORSE	Coarse / Fine control
12	GSMSLEW	Slew / Track
11	-	
10	-	
9	GSMVE2	Velocity estimator 2 enabled (SAFE mode)
8	GSMTCF	Torque correction factors enabled
7	-	
6	-	
5	GSMVRIPL	Velocity ripple rejection enabled
4	-	
3	GSMTRIPL	Torque ripple rejection enabled
2	-	
1	-	
0	-	

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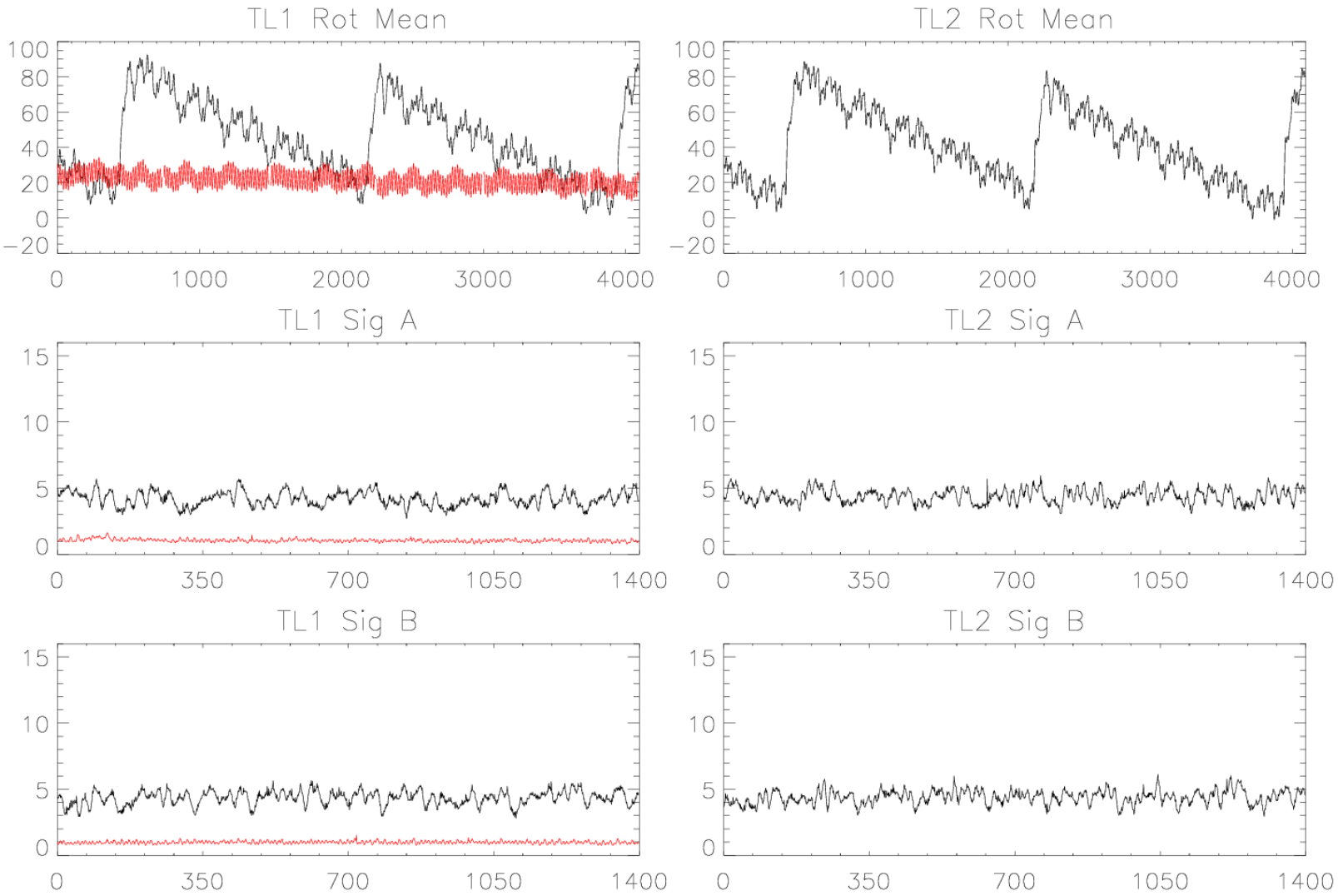
Torque Level Test GERB-1 vs. GERB-3



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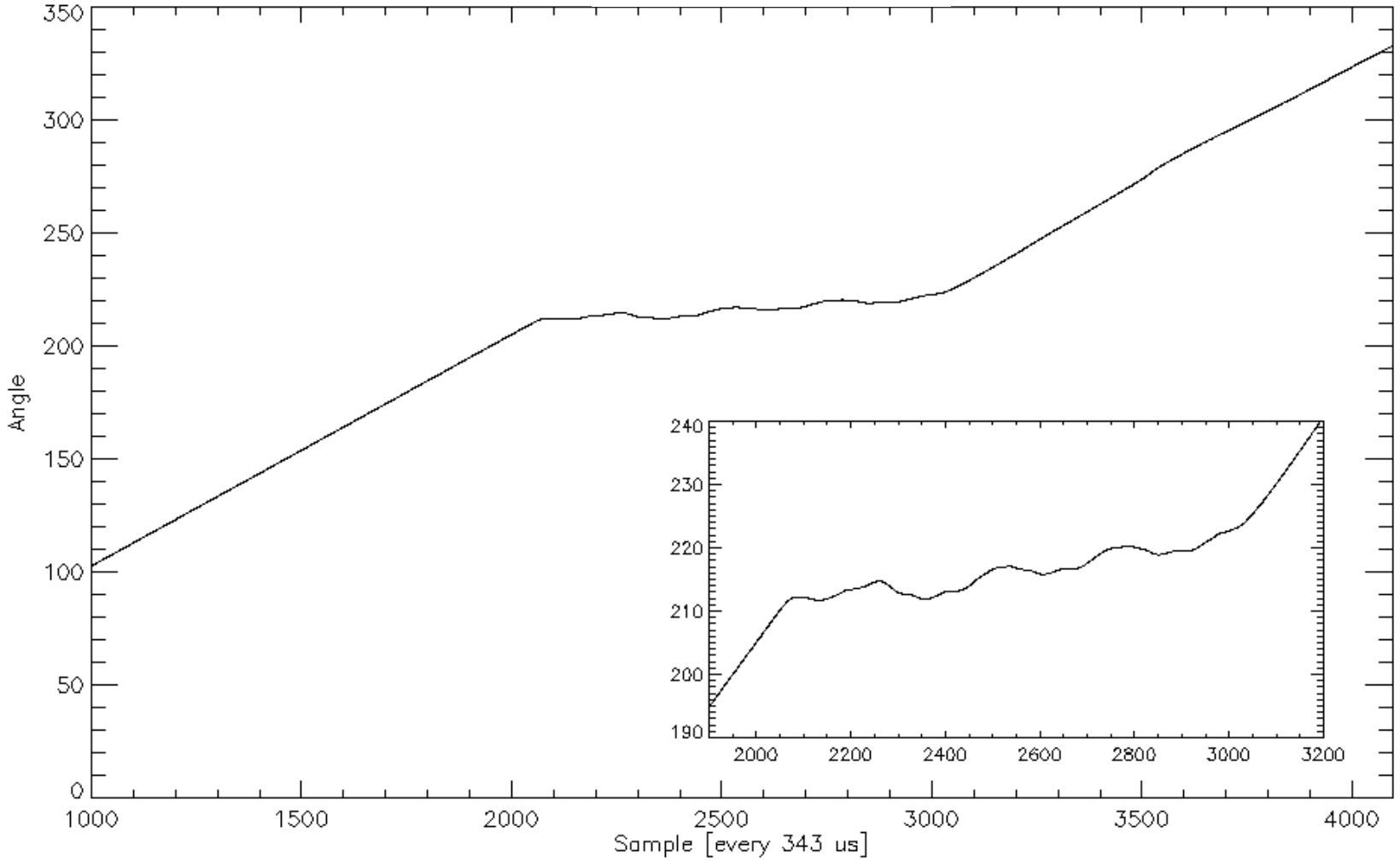
Mirror 'Pecking' on GERB-2, 17th August 2012



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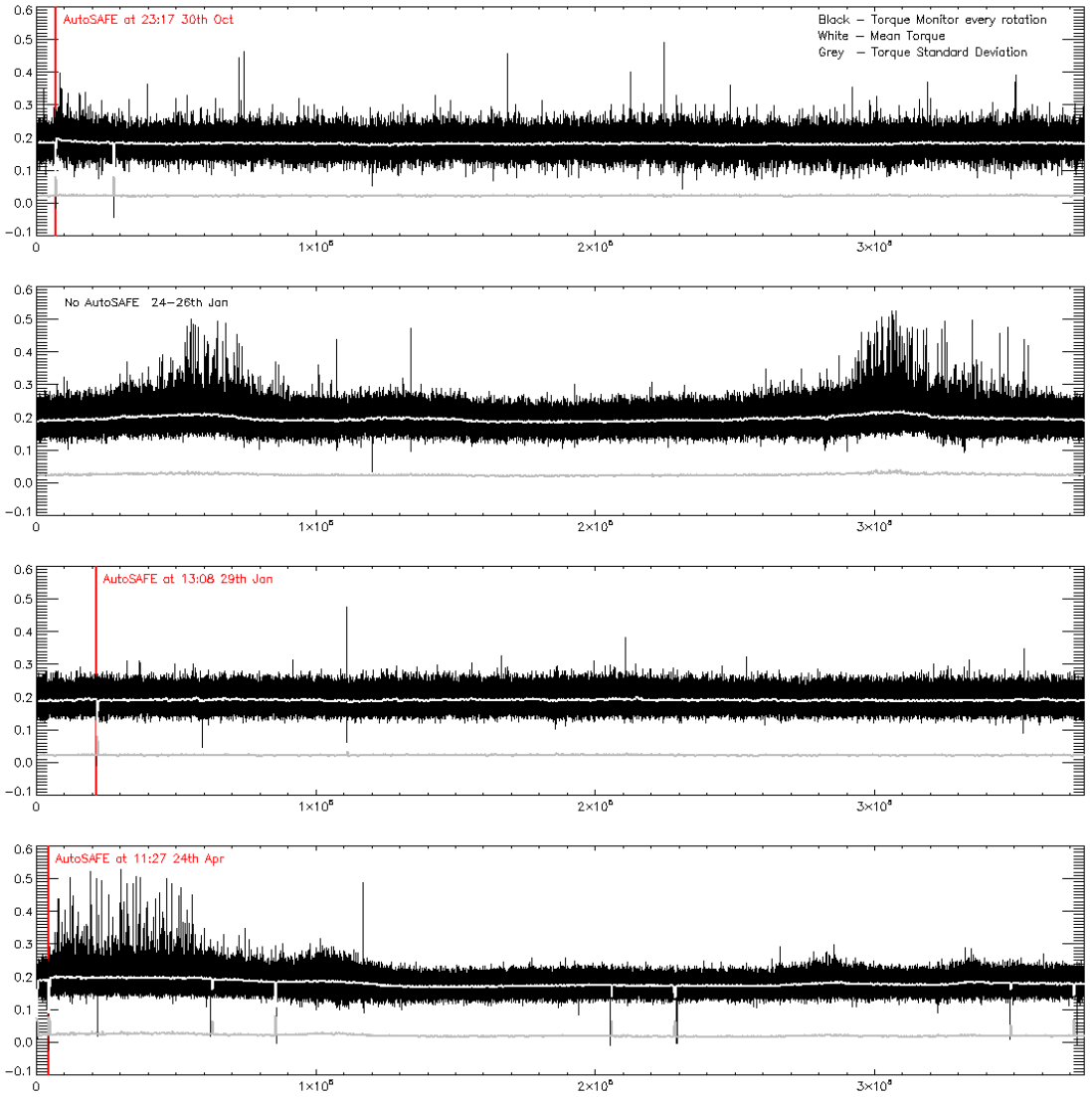
Connection between AutoSAFEs?

In analysis of the two DSM events on GERB-3 it was noted that they were both preceded by AutoSAFE events on the stray light checks.

To ensure no causal connection the torque monitor data was examined in those two incidents and the event from October.

Data is also shown from late in January 2013 when no safety transitions took place.

The proximity appears to be coincidental.



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Recovery Operations I

Date	Test/Operation	Notes	Result	VCS
22nd May	60° steps backwards from 300°	In SAFE mode, drive enabled	Torque reversal between 240° and 180° (response consistent with assumed mirror position between 0° and 60°) no discernible DMS movement	0x4200 Fine, Track, VE2
23rd May	+/-90° from 15° FIFO position	In SAFE mode, drive enabled. 40 mins, 10 minutes per command.	Torque reversal but insignificant DMS movement (1 bit flip)	0x4200 Fine, Track, VE2
28th May	Command to SUNBLOCK	Non standard VC Mode	Small VDEM values, continuous torque reversal (nominal for 0x7200.) No discernable DSM movement.	0x7200 Coarse, Slew, VE2
29th May	Command to SUNBLOCK	New VC mode	Full scale VDEM value oscillation, continuous torque reversal (nominal for 0x6200.) No discernable DSM movement.	0x6200 Coarse, Track, VE2
5th June	Full rotation at 7.2° steps	DSM disabled. Test position error response.	Drive system position error shows system apparent position between 36° and 43.2°. Consistent with backward sweep result.	0x1200 Fine, Slew, VE2

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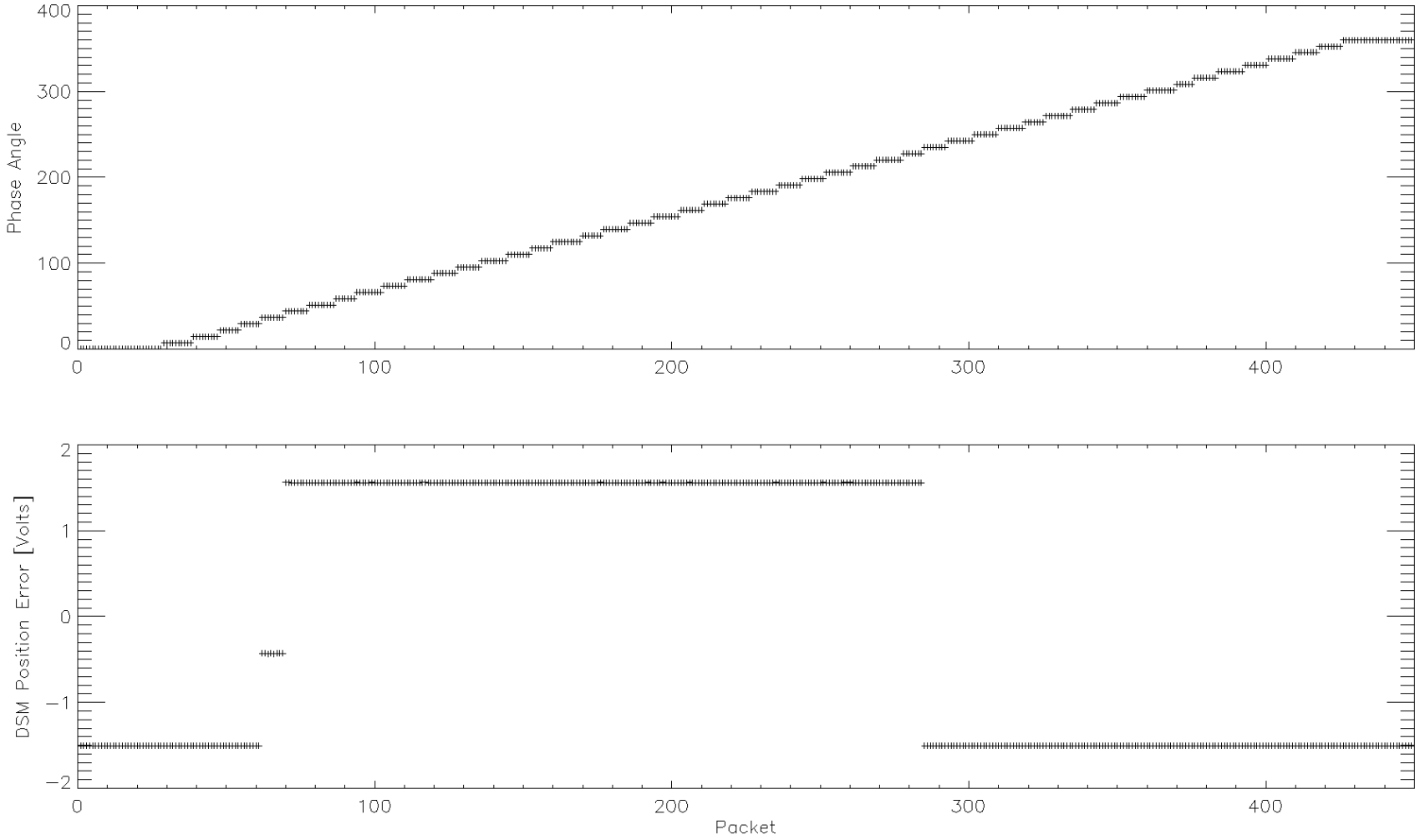
Mirror Phase Sweep through 360°



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Recovery Operations II

Date	Test/Operation	Notes	Result	VCS
12th June	Fine scan from 33.975° to 40.05°, power cycle, repeat full scan 360° @ 7.2°	DSM disabled. Test position error response.	Apparent position 36.82°. Second test failed due to lack of timing board initialization.	0x1200 Fine, Slew, VE2
13th June	Repeat 360° @ 7.2°	Command to SUNBLOCK then back to SAFE to initialise timing board.	Control system apparent position unchanged within digitisation limit.	0x1200 Fine, Slew, VE2
17th June	+5º/0/-5º/0 x10 @2s and 5s intervals	Rapid command of discrete DSM positions around apparent position.	Torque reversal seen but no lock or significant movement.	0x4200 Fine, Track, VE2
18th July	Constant Rotation	New VC states which omits torque loop used.	Constant rotation not achieved.	0x4201-4207
18th July	'Kick' Test	Exploit behaviour seen in ground testing. High torque generated by switching power relay to DSM last in SUNBLOCK.	GERB-3 fails to achieve lock in SUNBLOCK when power restored.	0x4000 Fine, Track

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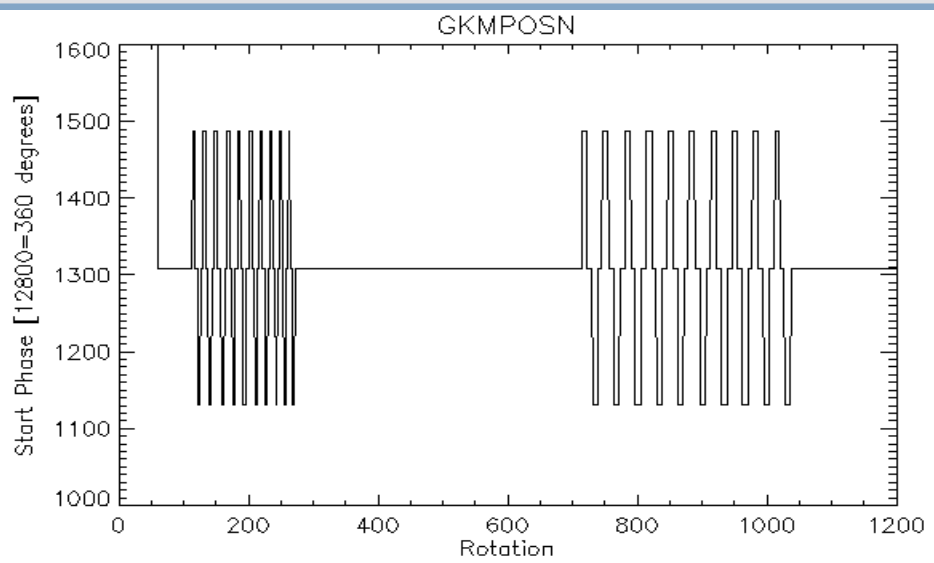
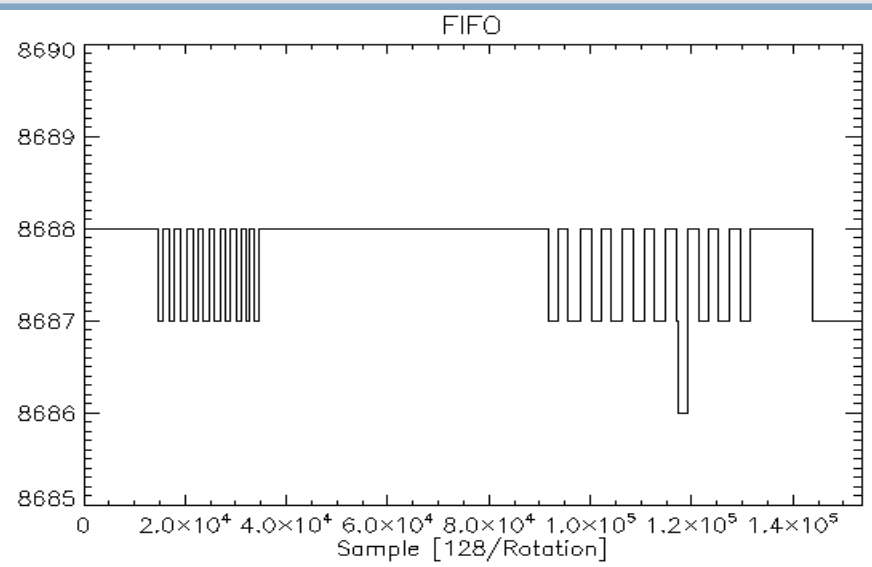
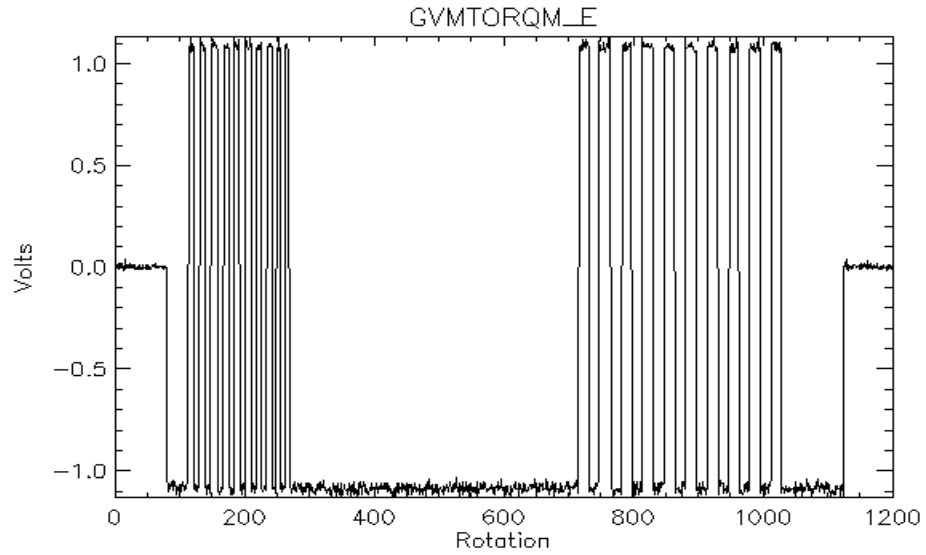
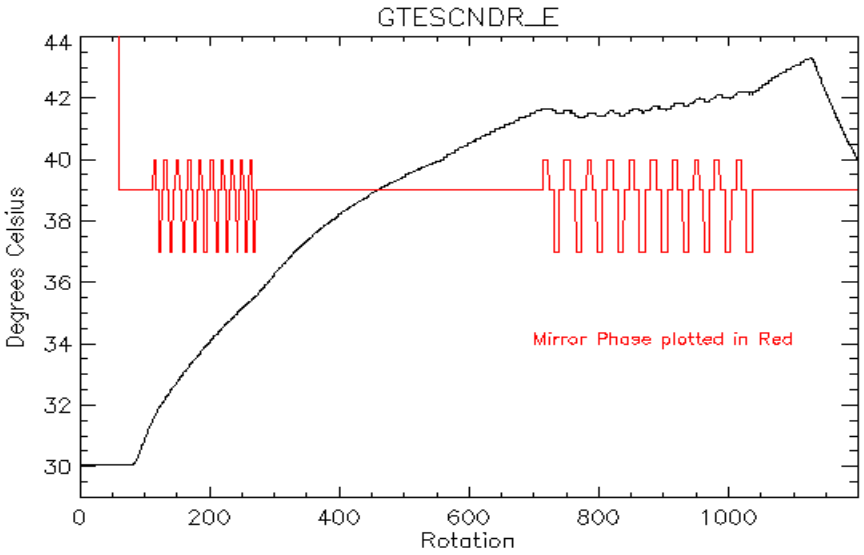
Mirror Pulse over +5/0/-5/0°









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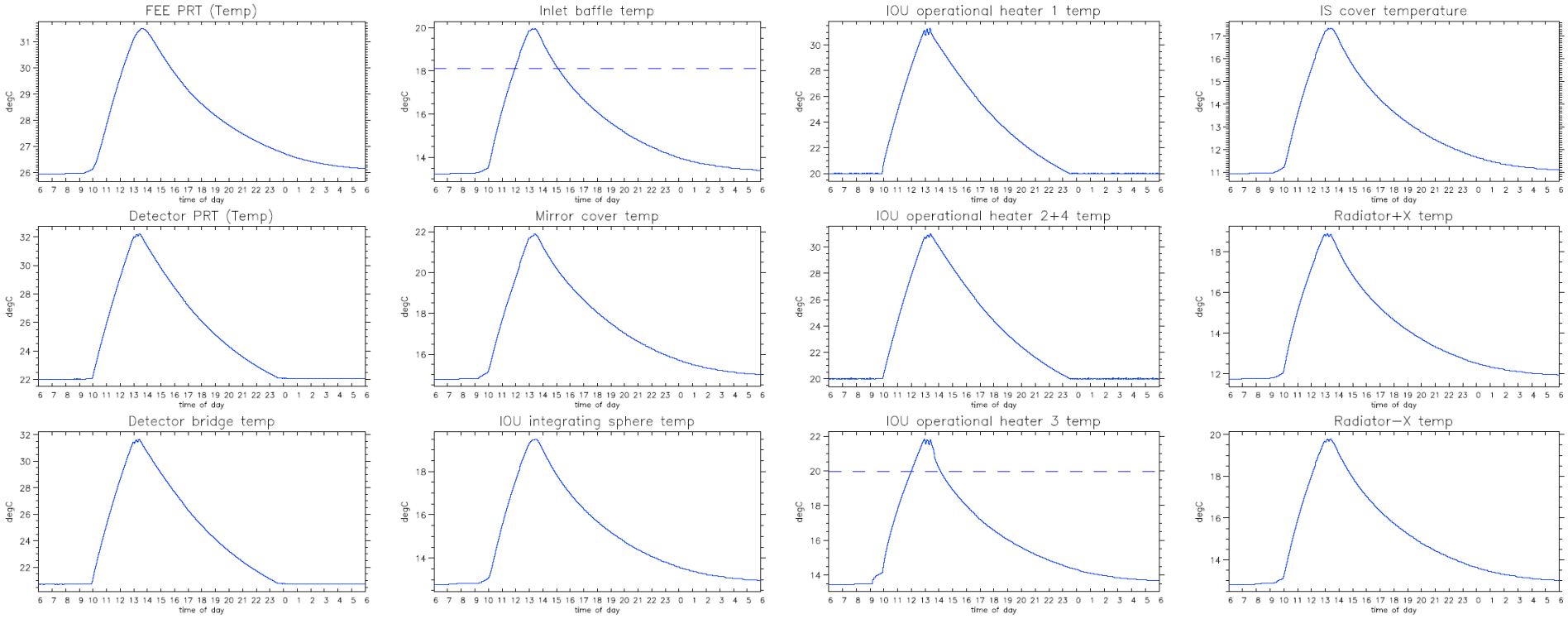
GERB-2 Heating Test

A planned test to heat the GERB-3 instrument and activate the DSM to free the mechanism led to a preparatory test on GERB-2.
The GERB operational heaters have insufficient power, and are poorly placed to preferentially heat the DSM so the survival heaters were used instead.
The succesful test showed that the GERB-3 baseplate could be raised 7 degrees without endangering the detector or adversely effecting SEVIRI full Earth scans.



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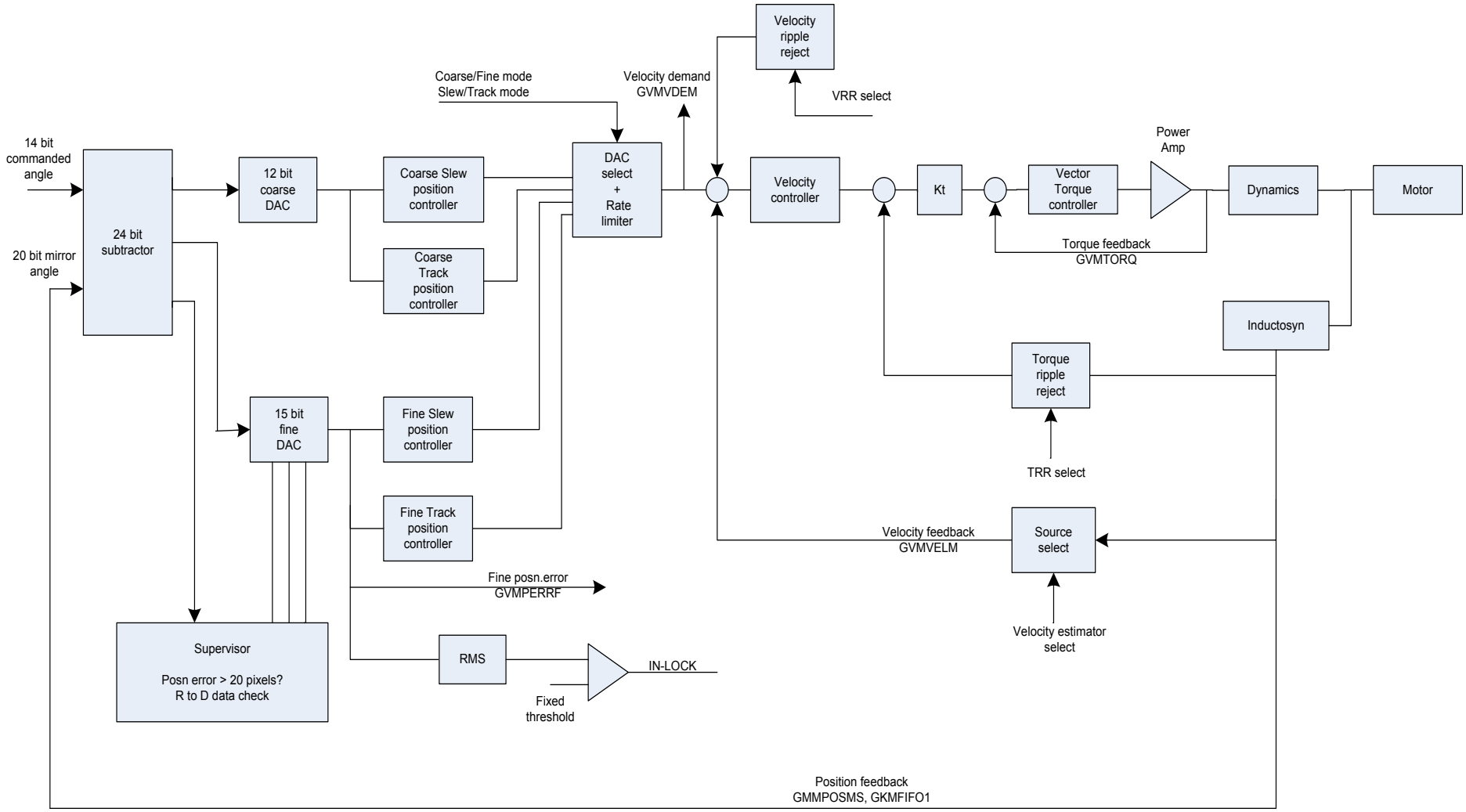
GERB-3 DSM Drive Logic



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Overview of GERB-3 DSM Anomalies

- GERB-3 has experienced two AutoSAFEs due to Despin Mirror (DSM) out of limits (OOL.)
- In early February the instrument was returned to NORMAL, with mirror lock achieved in SUNBLOCK after a power cycle.
- In late April the mirror failed to achieve lock in SUNBLOCK on two attempts to restart the mirror.
- In both case periodic high instrument currents which tripped the warning limits were observed short times after the AutoSAFEs.
- In AutoSAFEs not related to mirror performance these high currents were not observed and the mirror return to lock at the zero position over a few seconds.

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Relocation of MSGs